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*The Future of the
Yellowstone River...*

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JANUARY, 1977

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December 22, 1976

Early in 1975, this Department published the Yellowstone River Basin Water Resources Situation Report. Since then, many requests have been received for an update of that report to be available to the 45th Montana Legislature. Because of the present and potential conflicts over the use of Yellowstone Basin water and because of the importance of impending decisions on such matters as the reservation of Yellowstone water for future use, it seemed wise not only to report the up-to-date water situation in the Yellowstone Basin but also to project what levels of development could occur in the basin's future and what the impacts of that development might be. It also seemed advisable to make recommendations to the legislature and the Governor based on the Department's research and experience and on public comment received through Department programs. Those are the purposes of this report.

It is hoped that this information and these recommendations will prove valuable to the 45th Montana Legislature and the Board of Natural Resources and Conservation in the difficult decisions facing them, as well as to the thousands of Montana citizens and officials whose lives and occupations are inextricably tied to the state's water resources.

A draft of this report was distributed in October of 1976, and comments were solicited from other agencies and from the public. Many worthwhile suggestions were received for the revision of the report, most of which were incorporated in this final version. Unfortunately, because of time constraints and the unavailability of information, some excellent suggestions could not be used. Nevertheless, the Department thanks all who took the time to comment for their assistance in preparing this report.

Sincerely,

A handwritten signature in cursive script that reads "Orrin Ferris".

Orrin Ferris, Administrator
Water Resources Division

THE FUTURE OF THE YELLOWSTONE RIVER. . . ?

January 1977

Water Resources Division
MONTANA DEPARTMENT OF NATURAL RESOURCES
AND CONSERVATION

COVER PHOTO

The Yellowstone River near Mallard's Rest south of Livingston, with Mt. Delano and the Pine Creek and Deep Creek canyons in the background. Montana Fish and Game Department photograph by Craig Sharpe.

CONTENTS

FIGURES	iv
TABLES	v
ABBREVIATIONS USED IN THIS REPORT	vii
SUMMARY	1
CONCLUSIONS AND RECOMMENDATIONS	5
INTRODUCTION.	11
PART I. Water Resources of the Yellowstone River Basin	15
Surface Water Resources	
Ground Water Resources	
PART II. Present and Projected Water Requirements for	
Consumptive Use	23
Energy Water Use	
Water Use for Irrigated Agriculture	
Municipal Water Use	
Other Consumptive Water Use	
Water Availability for Projected	
Consumptive Use	
PART III. The Impact of Increased Development on Instream Water Uses	49
Channel Morphology	
Water Quality	
Fish and Wildlife	
Recreation	
PART IV. Water Rights.	61
Existing Water Rights	
Indian Water Rights	
Federal Water Rights	
Existing Water Rights Litigation	
Yellowstone River Compact	
PART V. Resolving the Conflicts--The State Water Plan	69
Potential Solutions to Some Water Conflicts in	
the Yellowstone Basin	
State Water Planning Programs	
APPENDIXES	79

Appendix A.	Conversion Tables	
Appendix B.	Major Requests for the Appropriation or Reservation of Yellowstone Basin Water	
Appendix C.	Methodology of the Irrigation Feasibility Study	
Appendix D.	Municipal Water Use in the Yellowstone Basin	
Appendix E.	Summary of Questionnaire Response	

LIST OF REFERENCES	105
------------------------------	-----

FIGURES

	Page
1. Average Monthly Flows of the Yellowstone River at Four Selected Stations.	18
2. The Nine Planning Subbasins of the Yellowstone Basin	25
3. Tongue Subbasin Monthly Outflows at the Low Level of Development.	41
4. Tongue Subbasin Monthly Outflows at the Intermediate Level of Development	42
5. Tongue Subbasin Monthly Outflows at the Reduced High Level of Development	43
6. Powder Subbasin Monthly Outflows at the Low Level of Development	45
7. Powder Subbasin Monthly Outflows at the Reduced High Level of Development	46
8. Lower Yellowstone Subbasin Monthly Outflows at the High Level of Development	47
9. The Status of the Water Rights Adjudication Process in the Powder River Basin	64
10. Preliminary Schedule for the Completion of the State Water Plan and Associated Studies	77

MAPS

	Follows Page
Strippable Coal Reserves	28
Potential Reservoir Sites and Major Industrial Water Applications	29
Irrigated and Irrigable Lands	33
Stream-Fishery Classification	57

TABLES

S-1.	Increased Water Requirements for Consumptive Use in the Yellowstone Basin in 2000	1
S-2.	Increased Water Requirements for Coal Development in the Yellowstone Basin in 2000	2
1.	Response by Montana Principal Impact Area Residents Polled to Statements about Coal Development	12
2.	Hydrologic Characteristics of Major Streams	19
3.	Yellowstone Basin Reservoirs with Total Capacities of 5,000 Acre-Feet or More	19
4.	Aquifer Characteristics	21
5.	Generating Capacity and Water Requirements for Thermal-Electric Plants in the Yellowstone Basin	26
6.	Hydroelectric Plants in the Yellowstone Basin	27
7.	The Projected Use of Coal Mined Annually by 2000 in the Yellowstone Basin	29
8.	The Increase in Coal Conversion in the Yellowstone Basin by the Year 2000	31
9.	The Increase in Water Depletion for Energy by the Year 2000 by Subbasin	32
10.	Feasibly Irrigable Acreage by Lift and Pipeline Length, High Level of Development	35
11.	Feasibly Irrigable Acreage by County and Subbasin by 2000, High Level of Development	36
12.	The Increase in Water Depletion for Irrigated Agriculture by 2000 by Subbasin	37
13.	The Increase in Water Depletion for Municipal Use by 2000	38
14.	The Increase in Water Depletion for Consumptive Use by 2000, by Subbasin	39
15.	Estimated Indian Water Requirements by the Year 2020.	66

16.	Division of Waters Under the Yellowstone River Compact	68
17.	Wyoming's Yellowstone Compact Estimates	68
18.	Storage and Cost Comparison of Selected Potential Yellowstone Basin Reservoirs	73
19.	Water Requirements for Coal-Fired Electric Generating Plants	75

ABBREVIATIONS USED IN THIS REPORT

af	acre-feet
af/y	acre-feet per year
b/d	barrels per day
cfs	cubic feet per second
gpm	gallons per minute
mgd	million gallons per day
mg/l	milligrams per liter
mmaf	million acre-feet
mmaf/y	million acre-feet per year
mmcf/d	million cubic feet per day
mmt	million tons
mmt/y	million tons per year
mw	megawatts
SNG	substitute natural gas
t/d	tons per day
TDS	total dissolved solids
\$/af/y	dollars per acre-foot per year

SUMMARY

This report presents an overview of the existing and possible future demands on the water resources of the Yellowstone River Basin and should assist the state legislature in making decisions related to the allocation of the waters of the basin. The Yellowstone River carries an average of 8.8 million acre-feet of water out of the state each year; much of that is available for use, but just how much, and where, and at what times of the year, are not confidently known, primarily because most water rights in the basin have not been quantified. Two of the tributaries, the Tongue and the Powder, are not, under current conditions, dependable sources for appropriation for additional continuous, year-round use or even for the full irrigation season.

In order to illustrate how much future development could reasonably be expected to take place in the basin, projections of future irrigation, municipal, and industrial development and water consumption are presented in this report. They were developed for a current Department of Natural Resources and Conservation (DNRC) study of the physical, biological, and economic effects of water withdrawals from the Yellowstone River. These projections for the year 2000 are summarized in tables S-1 and S-2; they are presented by subbasin elsewhere in this report.

Even though the overall water resource of the basin is adequate in quantity (average 8.8 mmf/y at Sidney) to satisfy the maximum increase (0.8 mmf/y) shown in table S-1, water availability is a problem. It will not be possible to meet all requirements at the times and places projected, due to seasonable variations in flow and local scarcity of water in some of the subbasins. In some areas, consumptive requirements would be satisfied only by sacrificing instream uses, providing additional storage, or establishing interbasin transfers of water with aqueducts.

TABLE S-1
INCREASED WATER REQUIREMENTS FOR CONSUMPTIVE USE
IN THE YELLOWSTONE BASIN
IN 2000

Level of Development	Irrigation		Municipal		Energy*	Total Increase** in Depletion (af/y)
	Acreage Increase	Increase in Depletion (af/y)	Population Increase	Increase in Depletion (af/y)	Increase in Depletion (af/y)	
Low	79,160	158,320	56,858	5,880	48,350	212,550
Intermediate	158,320	316,640	62,940	6,960	147,160	470,760
High	237,480	474,960	94,150	10,620	326,740	812,320

* Details of the water requirements for energy use are shown in table S-2.

** This total assumes that the same level of development occurs in all use categories.

TABLE S-2

INCREASED WATER REQUIREMENTS FOR COAL DEVELOPMENT IN THE
YELLOWSTONE BASIN IN 2000

Level of Development	Coal Development Activity						Total
	Electric Generation	Gasification	Syncrude	Fertilizer	Export	Strip Mining	
COAL MINED (mmt/y)							
Low	8.0	7.6	0.0	0.0	171.1		186.7
Intermediate	24.0	7.6	0.0	0.0	293.2		324.8
High	32.0	22.8	36.0	3.5	368.5		462.8
CONVERSION PRODUCTION							
Low	2000 mw	250 mmcf/d	0 b/d	0 t/d			
Intermediate	6000 mw	250 mmcf/d	0 b/d	0 t/d			
High	8000 mw	750 mmcf/d	200,000 b/d	2300 t/d			
WATER CONSUMPTION (af/y)							
Low	30,000	9,000	0	0	*	9,350	48,350
Intermediate	90,000	9,000	0	0	31,910	16,250	147,160
High	120,000	27,000	58,000	13,000	80,210	22,980	321,190

* No water consumption is shown for export under the low level of development because, for that development level, it is assumed that all export is by rail, rather than by slurry pipeline.

The dewatering that would result from increased consumption would affect the river system. There would be some effect, for instance, on the recreational activities in the basin. No perceptible impact would result from the activities associated with the low level of development. The high development level, however, would dewater the river to the point that boating, waterskiing, and other activities would be negatively affected. Fish and riparian wildlife would likewise be adversely affected by dewatering projected in the high level of development, especially in the tributaries. Water quality, especially in the Tongue and Powder subbasins, would be degraded sufficiently by the projected levels of development that severe constraints would be placed on the use of this water for irrigation and municipal purposes and by fish and wildlife.

Contributing to the difficulty of determining how much water is still available for use in the basin is the lack of quantification of existing water rights. The adjudication of existing rights in the Powder subbasin, now underway, is a time-consuming process. There are about 11,000 water rights, each of which must be investigated in the field. The status of Indian water rights is unclear. There can be no question of their existence, but their size is in dispute. Similarly, federal reserved water rights in the Yellowstone Basin have never been quantified. Current litigation, especially three lawsuits brought by or on behalf of the Crow and Northern Cheyenne tribes, may help resolve some of these issues concerning water rights.

There are questions concerning the Yellowstone River Compact. This agreement allocates to each of the two states a percentage of adjusted flows of the Yellowstone tributaries that flow out of Wyoming into Montana. However, it does not clearly define the assumptions needed to adjust flows before those percentages can be converted to actual volumes of water. As a result, the two states have not yet agreed on how to administer the compact.

There are potential solutions to some of these water conflicts. The reservation of water for future beneficial use, including instream flow maintenance, a provision of the Water Use Act of 1973, may help to ensure that existing consumptive use patterns (such as irrigated agriculture) are not restricted in their future development by lack of water and that instream needs are met. Increased storage in the basin could resolve some conflicts over water by making more available when needed. The choice of water-conservative conversion, cooling, and transportation methods for use by the energy industry and better water management by agriculture would reduce water depletion, freeing water for other uses. Complete adjudication of existing rights in the basin will ensure the protection of those rights and identify that portion of the basin's water still available for appropriation for consumptive use or for flow maintenance.

The investigation of these and other potential solutions, and recommendations for their implementation, will be the responsibility of the Department of Natural Resources and Conservation and will be a part of the State Water Plan, now being formulated.

A questionnaire concerning the conflicts and issues discussed in this report was distributed to the public and other agencies in October, 1976, with a draft version of the report; the response to that questionnaire is recorded in appendix E. Because no effort was made to provide a scientific sampling of basin residents as respondents to the questionnaire, none of the recommendations presented in the following section of this report is based solely on the questionnaire response.

CONCLUSIONS AND RECOMMENDATIONS

A draft version of this report, entitled Which Way? The Future of Yellowstone Water, was printed in October, 1976. It was distributed by mail to public and private agencies and interested individuals. Copies were also distributed to the public at meetings conducted by the DNRC in six Yellowstone Basin communities. Based on comment received at those meetings, written comment on the draft submitted by mail, and the research and experience of the DNRC in the Yellowstone Basin as presented in this report, the DNRC makes these recommendations.

PREFERENCE RATING OF WATER USES

Based on the information presented in this report, it can be concluded that there will not be enough water in all areas of the basin at all times of the year to satisfy all potential water users. In particular, the Tongue and Powder river basins may be water short if future development approaches the level considered in this report. If that is the case, it may not be to the state's advantage to apply the "first in time, first in right" principle as the sole method of determining future appropriations of water for beneficial use. To promote the orderly and wise utilization of Montana's water and related land resources, the state may find it helpful to adopt a system of rating water uses for the purpose of showing preference to one use over another, subject, of course, to existing water rights. Systems like this are now in effect in several states, including Wyoming, as well as the Canadian province of Saskatchewan. The DNRC recommends that the 45th Montana Legislature require the Legislative Council to report to the 46th legislature, after consulting with the DNRC and other appropriate state agencies, on the feasibility of implementing such a preference system throughout Montana or within critical water basins.

ADJUDICATION AND DEFENSE OF WATER RIGHTS

Montana is now involved in several large-scale challenges, in the form of lawsuits, to the state's system of administering water rights. It can be expected, especially considering the precedent-setting nature of such developments as the potential reservations of water for future use, that more such litigation will be initiated in the future, involving not only state government but also individual water-right holders. In light of this, the present rate at which the adjudication process in Montana is proceeding is too slow. The DNRC has taken the position that the proper forum for the determination of all existing water rights, federal, Indian, and private, is the state district court. A recent U.S. Supreme Court decision supports that position, but only based on the willingness and ability of the states to adjudicate existing water rights. Therefore, Montana should be able to demonstrate that the state is not only willing but able to complete adjudication within a reasonable time.

As the DNRC gains experience and establishes procedures for adjudication, the rate of adjudication will increase; even so, given DNRC's current manpower levels, and the fact that the adjudication process in Montana was started 60 to 70 years later than in other western states, it will be a long time before the entire state is adjudicated. In the Yellowstone Basin, even though it will probably be completely adjudicated before the Missouri or Columbia basins, that delay could result in overappropriation of some streams. Money and time could be wasted in the development of projects for which the water supply is not dependable enough to justify construction. To prevent that, adjudication must be speeded up, and that will require additional funding. The DNRC has found that it is not wise to hire technicians who do not have adequate education and experience in water rights investigation; the process is complex, and training new technicians takes too much time. The DNRC budget proposal for the next biennium included a request for \$190,000 for five new full-time positions and associated expenses in the Water Rights Bureau. The DNRC recommended to the Governor that the DNRC be budgeted that amount for the hiring of qualified adjudication personnel. It was also recommended that a legal defense fund of \$250,000 be budgeted in the next biennium to be used for expenses incurred in the legal protection of existing and future water rights.

MORATORIUM EXTENSION

The Water Moratorium Act of 1974 (Sections 89-8-103 et seq., R.C.M. 1947) provided the state with the opportunity to guide the future use of Yellowstone Basin water by granting reservations of water (under Section 89-890, R.C.M. 1947) for future beneficial use or for instream flow requirements before considering any more applications for the appropriation of large amounts of water. Unless the applications for water reservations received to date are acted upon before the expiration date of the moratorium or any extension of it, that opportunity may be lost. Several factors will make it very difficult, if not legally impossible, to act by March 10, 1977, the moratorium's present expiration date.

One problem is the complexity of the issue. Each of the 30 water reservation applications, some of them very detailed and involving a great many of the basin's streams, must be considered individually. Hearings must be conducted; complex legal questions must be investigated. Complicating the matter further is the lack of a precedent. Montana is believed to be the first state to attempt to establish such a reservation system, especially in conjunction with a moratorium on large appropriations.

Another problem is the potential for delays in the hearing process. The DNRC's experience in the past with hearings held under the Montana Water Use Act of 1973 has been that there are numerous causes for delays; should these delays occur in the process of conducting hearings on the water reservation applications, the Board's action on those applications could be delayed past March 10.

Another consideration is the potential for changes in the makeup of the Board of Natural Resources and Conservation. Because of resignations and the expiration of terms, some of the seven Board members may have held that position barely two months at the time they will decide which, if any, applications for the reservation of Yellowstone Basin water should be granted.

The implication of these circumstances is that the moratorium should be extended until the Board has had a reasonable time to act on the reservation applications. There are good reasons, however, for extending the moratorium for a longer period. The State Water Plan for the Yellowstone Basin, originally scheduled to be completed by now, has been slowed by delays in the Missouri River Basin Commission Level B Study. The current schedule calls for completion of the State Water Plan for the Yellowstone Basin by June of 1978. At that time, one major action which will affect the future of Yellowstone Water--reservations--will have been taken. Nevertheless, there will undoubtedly be further water allocation questions, likely involving establishing preference of water uses, a concept recommended above for study. The 46th Montana Legislature in 1979 will be the first to have the opportunity to make an informed decision on the establishment of such a preference system. Other considerations involved with future water allocation include quantification of federal and Indian reserved rights and resolution of the Yellowstone Compact with Wyoming.

Furthermore, the State Water Plan will have broader considerations than future water allocation. Included may be recommendations regarding recreation, water management, flood control, erosion and sedimentation, and pollution control.

If the Yellowstone Moratorium is allowed to expire and the processing of applications for large diversions and storage is continued, then options for state control of the magnitude and type of water development in the Yellowstone Basin may be foreclosed. On the other hand, if the State Water Plan is completed and the 46th Montana Legislature is able to act on recommendations of that plan before the expiration of the moratorium, then the future of Yellowstone water development and conservation should be more rational and will more likely reflect the public interest.

Based on these considerations, the DNRC recommends that, as a minimum, the 45th Montana Legislature extend the Yellowstone Moratorium until the Board of Natural Resources and Conservation has had a reasonable length of time to act on requests for the reservation of Yellowstone Basin water under the Montana Water Use Act of 1973.

WATER STORAGE

Because water availability is likely to be a problem in the Tongue and Powder river basins, potential methods of solving or preventing that problem should be investigated. The DNRC recommends that the 45th Montana Legislature adopt a resolution that will direct the DNRC to:

- 1) enter into discussions with Wyoming on the possibility of initiating joint studies on proposals for augmenting water supplies in those basins;
- 2) investigate with potential users water marketing possibilities in those basins; and

- 3) conduct special studies on water quality and saline seep potential in the Tongue and Powder river basins, on the effects of increased storage and irrigation on those factors, and on aqueduct system alternatives to storage.

The DNRC also recommends that the legislature include in the resolution an allocation of funds sufficient to enable the DNRC to conduct these special studies and, if it is determined to be appropriate, to pursue feasibility (Level C) studies for storage projects on those rivers.

SLURRY PIPELINES

The least water-consumptive method of developing Montana's coal would be by exporting the coal by rail for conversion to more usable forms of energy elsewhere. The most water-consumptive are combination conversion-transmission processes, such as thermal-electric generation and electrical transmission or coal gasification and SNG pipelines. In between, in terms of water consumption, are coal slurry pipelines. In fact, based on information available to the DNRC, it would take approximately one-fifth the amount of water to ship a given amount of coal by slurry as to convert it in Montana.

If coal is to be mined and exported, then it should certainly be transported by the existing rail system. However, even with improvements such as double tracking and centralized, automated controls, that system is finite in its capacity to haul coal without the construction of new lines and the associated increase in impacts. If coal mining expands to the point that the rail system reaches its capacity, then a decision must be made among four alternatives:

- 1) expand the rail system by constructing new lines;
- 2) convert the coal to electricity or synthetic fuels to be exported by transmission lines or pipelines;
- 3) export coal by slurry pipelines; or
- 4) attempt to restrict mining to that level of rail capacity.

The long history of rail transportation in the Northern Great Plains has led to an understanding of the impacts of railroads on social, economic, and environmental systems. Coal conversion and transmission facilities have been studied in recent years, although their broad implications need additional research.

The DNRC recommends that the legislature direct, through resolution, that the DNRC evaluate existing and ongoing studies of slurry pipelines and make a report and recommendation to the 46th legislature of the costs and benefits to Montana of using water for slurry pipelines.

YELLOWSTONE COMPACT

One severe hindrance to water planning in Montana is that many legal constraints imposed by Montana's signing of the Yellowstone Compact have not yet been defined. Because each state's share of the flow of interstate tributaries

has not been quantified, it is not known how much, if any, of the flow of these streams is available for further appropriation in Montana. Little has been done to resolve these conflicts in the twenty-five year history of the compact, and, apparently, little will be done until Montana and Wyoming begin to cooperate at the highest level to solve these difficulties. Through its compact commission representative, Montana has for the past two years been attempting to achieve a greater degree of cooperation with Wyoming in the administration of the compact. These attempts will continue to be diligently pursued.

INTRODUCTION

It has now been five years since the publication of the North Central Power Study (North Central Power Study Coordinating Committee 1971), a product of the Bureau of Reclamation in cooperation with 35 major private and public electric power suppliers. The study identified 42 potential power plant sites in the five-state (Montana, North and South Dakota, Wyoming, and Colorado) northern great Plains region, 21 of them in Montana. These plants, all fired by northern Great Plains coal, would generate 200,000 megawatts (mw) of electricity, consume 3.4 million acre-feet per year (mmaf/y) of water, and result in a large population increase.

For many residents of Montana, that report was a confirmation of what had previously been an unpleasant, unsubstantiated belief: that massive development of eastern Montana's coal threatened to deplete the state's water resources, vastly increase our population, and irreparably alter a prized and envied way of life. Others welcomed it as a promise of economic boom. In either case, the passing of five years has brought substantial changes in the way most informed observers expect coal development to proceed in eastern Montana. Administrative, economic, legal, and technological delays have kept most of the conversion facilities identified in the North Central Power Study as necessary for 1980 on the drawing board or in the courtroom. There is now no chance of their being completed by that date or even soon after, which will delay and diminish the economic benefits some basin residents expected as a result of coal development. On the other hand, contracts have been signed for the mining of large amounts of Montana coal and applications approved for new and expanded coal mines and for Colstrip Units 3 and 4, twin 700-mw, coal-fired, electric generating plants.

One of the first manifestations of Montana's concern that there will not be enough water in the basin for all anticipated uses and that existing patterns of water use may suffer was the passage of significant legislation. The Water Use Act of 1973, which, among other things, mandates the adjudication of all existing water rights and makes possible the reservation of water for future beneficial use, was followed by the Water Moratorium Act of 1974, which delayed action on major applications for Yellowstone Basin water for three years. Several Yellowstone water studies were undertaken at the state and federal levels.

Early in 1975, the Montana Department of Natural Resources and Conservation (DNRC) published the Yellowstone River Basin Water Resources Situation Report. In May of that year, the DNRC conducted a series of meetings in eight Yellowstone Basin cities (Sidney, Glendive, Miles City, Broadus, Forsyth, Hardin, Billings, and Livingston) to present the information contained in the Situation Report and record public sentiment about water planning and water conflicts. In almost every city, the possibility of lower flows in the Yellowstone as a result of increased development in the basin emerged as a primary concern. In many of the cities, participants worried:

- 1) that available water would go to industry rather than agriculture because industry can afford to pay more,
- 2) that lower flows in the Yellowstone and strip mining might adversely affect the supply of ground water,
- 3) that a request from the Montana Department of Fish and Game for the reservation of 7.1 mmf/y of Yellowstone water (since amended to 8.2 mmf/y) for instream flows for fish and wildlife habitat was too high, and
- 4) that adjudication of water rights in the basin was proceeding too slowly, and major development might take place before existing rights are adequately protected by adjudication.

Some participants perceived the conflicting demand for water in the Yellowstone as competition between the energy companies and the agriculturalists, with the federal government on the side of the energy companies.

In a 1975 survey of public opinion on future water use in the Yellowstone Basin, concern was expressed that agriculture might be an unsuccessful competitor for water with energy, as shown in table 1.

TABLE 1
RESPONSE BY MONTANA PRINCIPAL IMPACT AREA RESIDENTS POLLED
TO STATEMENTS ABOUT COAL
DEVELOPMENT

Statement	Response, in percentage of valid responses		
	Agree	Disagree	Neutral
There is enough water to satisfy the needs of the coal industry and for expanding agriculture as well.	42.9	38.8	18.2
Water that is needed for crops will be used up by the coal development industry.	41.6	39.9	18.5
Transfer from agricultural water rights to industry should be allowed.	7.1	78.6	14.3

SOURCE: Montana University Joint Water Resources Research Center 1976.

Whether the mass depletions and irreconcilable conflicts apparently feared by some will ever occur is debatable; recent projections (those presented in this report, for example) have shown a future energy industry far less thirsty than the one projected in earlier attempts. There is every indication that, in the year 2000, irrigated agriculture will still be by far the largest consumptive water use in the basin. But the existing concern over allocation of Yellowstone water resulted not from projected increases in irrigation (or even from the large increases in irrigation accomplished since 1971), but from the projected use of water for energy.

And that concern is warranted. Even though there will apparently be enough water in the Yellowstone mainstem for all projected consumptive uses, water availability is already a problem in some tributaries, and the projected increases in depletion in those tributaries are major. When instream uses, such as the dilution of wastes and the provision of fish and wildlife habitat, are considered, there may be conflicts even on the mainstem. This report documents many such conflicting demands for water in the Yellowstone Basin; they must be resolved, one way or another, and some of them soon.

The purpose of this report is to assist in that process by providing information, by providing recommendations to the governor and the legislature, and by obtaining the opinions of the public and of other agencies regarding alternative future levels of development and potential solutions to water use conflicts. A draft of this report was published in October of 1976. That same month, six public meetings were held in the Yellowstone Basin at which that draft was presented and a related questionnaire distributed. Public comments at those meetings, as well as written comments received since then, were noted; the questionnaire responses were tabulated (see appendix E). These comments were considered in the preparation of this final report and in the formulation of recommendations.



*Water Resources of
the Yellowstone River Basin*

PART I

The Yellowstone River Basin includes much of northern Wyoming, southeastern Montana, and a small portion of western North Dakota. It is bounded by the Rocky Mountains on the west, the Missouri Basin on the north, the Little Missouri and Cheyenne basins on the east, and the Platte Basin on the south. The total drainage area, with a length of about 440 miles and a maximum width of 320 miles, encompasses 70,400 square miles. Wyoming contains 51 percent of the drainage basin; Montana, nearly 48 percent; and North Dakota, about 1 percent. Information presented in this report concerns the Montana portion of the basin.

SURFACE WATER RESOURCES

QUANTITY

The Yellowstone River originates in Wyoming and flows northeasterly through Montana. The primary source of Yellowstone Basin water is the snowpack that accumulates in the mountains during the winter. Surface runoff from this snow normally begins in April and reaches a peak in late May or early June. The average monthly flows that occur during this time are 5 to 10 times the average flows that occur in fall and winter months. This runoff is significantly reduced in late July, after which normal summer flows may be modified by diversions or summer rains. Figure 1 illustrates average monthly flows of the Yellowstone River at Livingston, Billings, Miles City, and Sidney.

The average annual flow of the Yellowstone River at Sidney, adjusted to the 1970 level of depletion, is 8.8 mmf/y (see table 2), approximately 33 percent of which originates within Montana. Table 2 shows average, maximum, and minimum runoffs of the Yellowstone River and its tributaries.

In the plains region, critically low flows, approaching no flows in some streams, occasionally occur in the fall, causing serious water availability problems for irrigators and affecting fish and wildlife.

Seven reservoirs in the basin (table 3) have total capacities of 5,000 acre-feet or more. These reservoirs provide over 1.5 mmf of water storage for agricultural, municipal, industrial, recreational, and flood-control purposes.

QUALITY

In the headwaters of the Yellowstone River Basin, water quality is almost always excellent, although there are site-specific, mining- and agriculture-related problems with erosion, sedimentation, pH, and heavy metals. The cold-water trout fisheries of the headwaters and upper reaches are among the nation's finest.

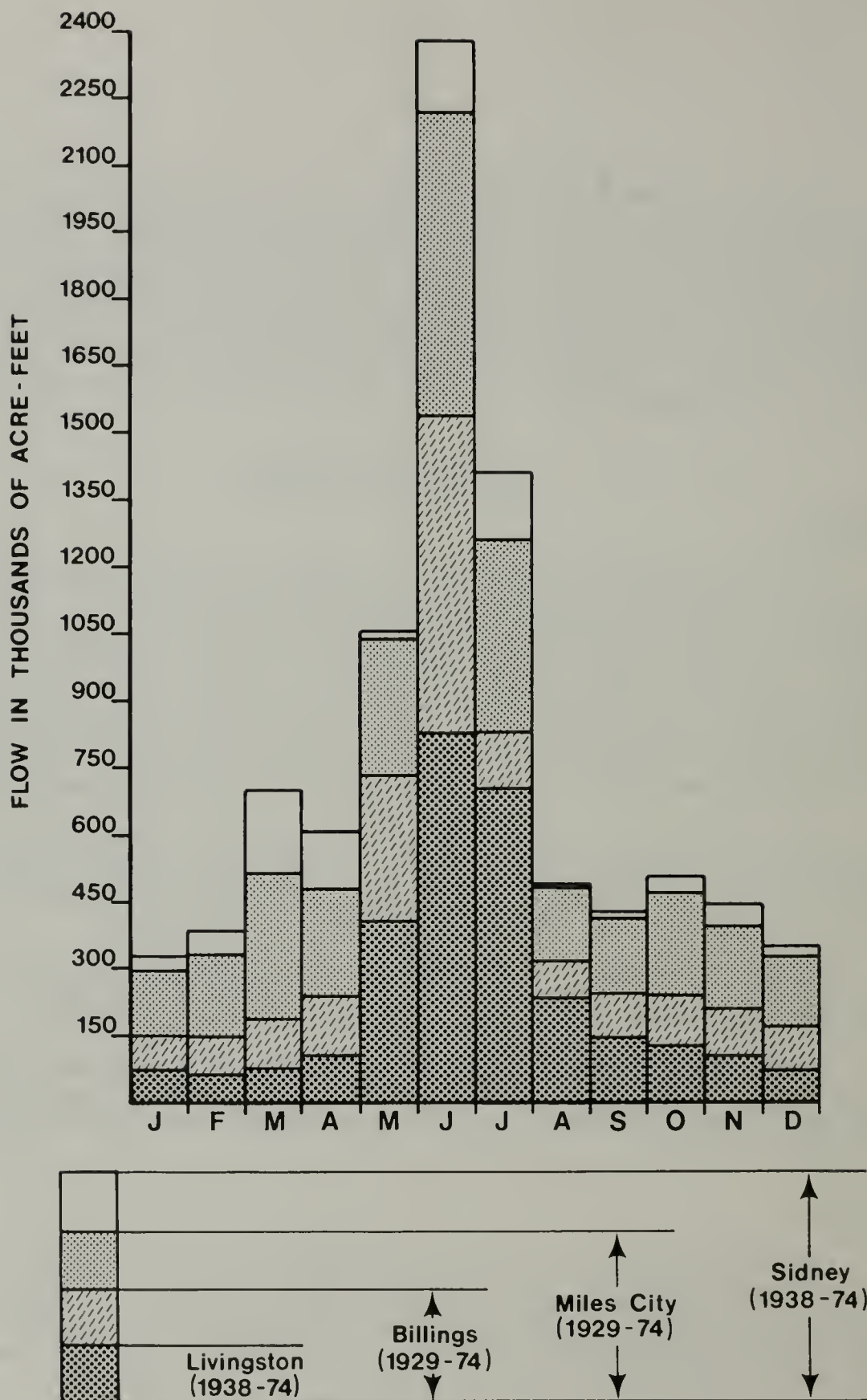


Figure 1. Average Monthly Flow of the Yellowstone River at Four Stations

TABLE 2
HYDROLOGIC CHARACTERISTICS OF MAJOR STREAMS
(acre-feet)

Stream	Location of Station	Average Annual Runoff		Maximum Recorded Annual Runoff		Minimum Recorded Annual Runoff	
		1970 Level of Development*	Historical**	Runoff	Year	Runoff	Year
YELLOWSTONE RIVER	near Livingston	2,687,000	2,722,000	3,792,000	1971	1,760,000	1931
BOULDER RIVER	Big Timber	unknown	441,200	611,600	1971	269,600	1961
STILLWATER RIVER	near Absarokee	unknown	695,500	1,029,000	1943	368,100	1936
CLARKS FORK YELLOWSTONE RIVER	near Silesia	767,000	908,500	1,015,000	1972	708,100	1973
YELLOWSTONE RIVER	Billings	4,920,000	5,008,000	7,396,000	1943	2,915,000	1934
BIGHORN RIVER	Bighorn	2,550,000	2,828,000	3,983,000	1947	1,175,000	1961
TONGUE RIVER	Miles City	304,000	309,400	532,100	1971	41,440	1961
YELLOWSTONE RIVER	Miles City	8,102,000	8,274,000	12,060,000	1943	4,446,000	1934
POWDER RIVER	near Locate	416,000	446,300	1,178,000	1944	57,500	1961
YELLOWSTONE RIVER	near Sidney	8,800,000	9,420,000	13,800,000	1924	4,209,000	1934

SOURCES: NGPRP 1974 and unpublished, Montana DNRC unpublished, USDI 1974.

NOTE: All measurements shown are based on water year (October 1 through September 30) rather than calendar year (January 1 through December 31).

*1970-level-of-development flows are averages calculated from historical records that have been modified to show the effects of 1970-level depletions in each year of study.

** The periods of record vary for these stations.

TABLE 3
YELLOWSTONE BASIN RESERVOIRS WITH
TOTAL CAPACITIES OF 5,000 ACRE-FEET
OR MORE

Reservoir	Stream	Total Storage Capacity (acre-feet)
Yellowtail Reservoir	Bighorn River	1,375,000
Tongue River	Tongue River	69,439
Cooney	Red Lodge Creek	24,190
Willow Creek	Lodge Grass Creek	23,000
Mystic Lake	West Rosebud Creek	20,800
Lake Walvoord	Sweet Grass Creek	14,000
Lake Adam	Sweet Grass Creek	11,000

As streams flow into the plains and merge, they commonly undergo a transition to a warm-water fishery resulting from the decrease in gradient and the increase in temperature and concentration of total dissolved solids. This transition is sometimes considered a degradation since the water becomes less suitable for domestic use and, eventually, unsuitable for the growth and propagation of salmonid fishes. However, the plains waters support a healthy, diverse, and increasingly popular warm-water fishery and an extensive irrigated agriculture. The general absence of municipal and industrial pollution is indicated by high dissolved oxygen concentrations and low fecal coliform (bacteria) counts.

The Clarks Fork Yellowstone and its plains tributaries exhibit poor-to-fair water quality. Total dissolved solids (TDS) and sediment concentrations are high due to the geology of the lower basin and to agricultural practices.

The Bighorn was once a major source of sedimentation in the Yellowstone mainstem. When the gates of Yellowtail dam were closed in 1965, the sediment load of the Bighorn was reduced as much as 80 percent and of the Yellowstone mainstem at Sidney up to 20 percent. TDS concentrations in the Bighorn usually exceed 500 milligrams per liter (mg/l), the recommended upper limit for drinking water.

The Tongue River Reservoir has likewise reduced the sediment load of the Tongue River, which now contributes a very small part of the sediment load of the Yellowstone mainstem. TDS concentrations in the Tongue often exceed the recommended upper limit for drinking water.

Of the major tributaries, the Powder River has the poorest quality. The Powder contributes only about 5 percent of the Yellowstone's water but nearly half of the sediment. TDS concentrations are often high enough that they would adversely affect the production of some irrigated crops.

Despite the poor-quality water of many of the plains tributaries, the Yellowstone mainstem maintains at least fair water quality throughout. Water quality has improved in the reach immediately downstream from Billings in recent years (Klarich 1976 and Montana DHES 1972); formerly, organic pollution from the city, from oil refineries, and from meat processing plants caused a serious depletion of the stream's dissolved oxygen. Downstream, at Sidney, TDS concentrations are less than the recommended upper limit for drinking water most of the year. The river's capacity to transport sediment is greater throughout its length than the sediment load; however, siltation of diversions and backwaters is sometimes a problem.

GROUND WATER RESOURCES

While shallow alluvial aquifers are limited to the valleys of the Yellowstone River and its tributaries, deep aquifers (including sandstones and coals in the Fort Union Formation, sandstones in both the Fox Hills and Hell Creek formations, and limestones in the Madison Group) underlie much of the basin. The Fort Union and the Fox Hills-Hell Creek formations are important for providing small amounts of water for stock and domestic use. The highest potential for development of large, high-volume appropriations is found in the shallow alluvial systems and the limestones in the Madison Group. Quantity and quality of the ground water from these aquifers are extremely variable, as shown in table 4.

TABLE 4

AQUIFER CHARACTERISTICS

Aquifer	Depth from Surface (ft)	Yield (gpm)	TDS (mg/l)
Shallow	To 300	5 - 1,500	300 - 6,000
Madison Group	1,000 - 8,000	2 - 3,700	550 - 300,000

SOURCES: U.S. Department of the Interior 1972b and 1973, Rahn 1975.



*Present & Projected
Water Requirements for
Consumptive Use*

PART II

This section discusses the present consumptive use of water (with emphasis on energy, irrigation, and municipal water use) and presents projections of future consumptive use. The projections consist of three future levels of development (low, intermediate, and high) projected by this Department in a current study of the physical, biological, and economic effects of water withdrawals from the Yellowstone River. The study is funded by the Old West Regional Commission, conducted by this Department, and is herein called the Yellowstone Impact Study. Significant portions of the study were performed by the Montana Department of Fish and Game and by the Water Quality Bureau of the Montana Department of Health and Environmental Sciences.

For each of the three levels of development, projections were organized geographically into nine subbasins within the Yellowstone Basin: Upper Yellowstone, Clarks Fork Yellowstone, Billings Area, Bighorn, Mid-Yellowstone, Tongue, Kinsey Area, Powder, and Lower Yellowstone. Those subbasins are delineated in figure 2.

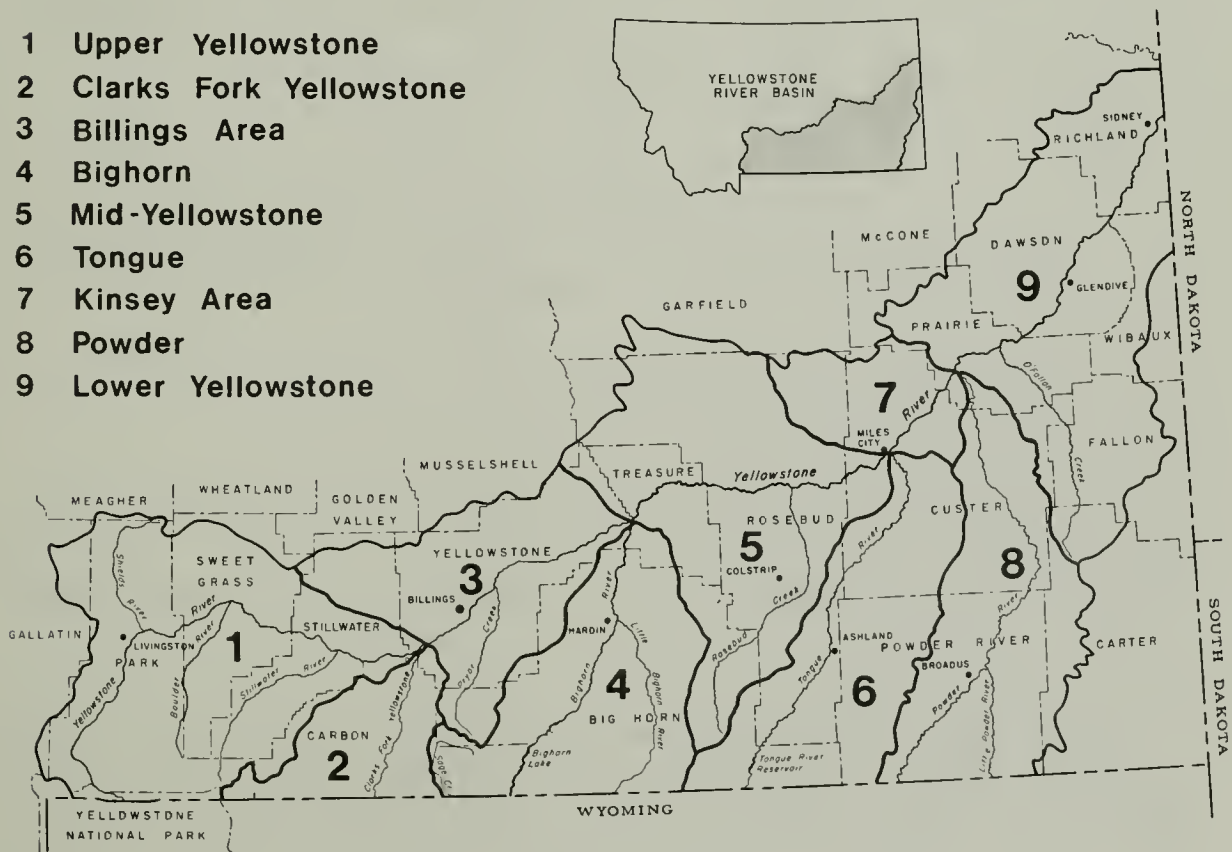


Figure 2. The Nine Planning Subbasins of the Yellowstone Basin

ENERGY WATER USE

PRESENT

The amount of water diverted for use in oil, coal, and gas production is relatively minor, and not all is actually consumed. Up to 172 million gallons per day (mgd) may be diverted for the cooling of the thermal-electric plants that generate 1030 mw of electricity (table 5). Colstrip Units 3 and 4, which were certified by the Board of Natural Resources and Conservation, will each have a nameplate generation capacity of 700 mw and will each use 10,700 acre-feet of water per year. Most of the water diverted for the four Colstrip units will be lost into the atmosphere during the cooling process. Other generating plants in the state consume less water because they utilize once-through cooling, a process that consumes very little water.

TABLE 5
GENERATING CAPACITY AND WATER REQUIREMENTS
FOR THERMAL-ELECTRIC PLANTS IN
THE YELLOWSTONE BASIN*

Name	Location	Fuel	Nameplate Generating Capacity (mw)	Diversion Requirement (mgd)***
Baker	Baker	Gas	1	negligible
Colstrip 1	Colstrip	Coal	350**	5+
Colstrip 2	Colstrip	Coal	350**	5+
Corette	Billings	Coal	180	82
Frank Bird	Billings	Oil	69	50
Glendive	Glendive	Gas	7	negligible
Miles City	Miles City	Gas	23	negligible
Sidney	Sidney	Coal	50	30
Total			1030	172

* Not shown are Colstrip Units 3 and 4, not yet constructed, which will have nameplate capacities of 700 mw each and will each require approximately 10 mgd of water, almost all of which will be consumed.

** Nameplate capacities of Colstrip Units 1 and 2 are 350 mw each; because of in-plant electrical requirements, only 330 mw can be delivered for transmission.

***Except for Colstrip Units 1 and 2, all plants shown in this table use once-through cooling and consume very little of the amounts diverted. Water for once-through cooling returns to the stream at a higher temperature than when it was diverted.

+ This approximate figure, derived from Montana DNRC 1974, includes some municipal water for the town of Colstrip. Almost all of this amount is lost to evaporation from the cooling towers during the cooling process

The Yellowtail and Mystic Lake hydroelectric generating plants (table 6) can produce up to 260 mw of power. While water used for hydroelectric generation is not consumed, reservoirs must be kept at certain levels for turbines to operate at maximum capacity, affecting water availability for downstream users. Water is consumed through evaporation from these reservoirs; however,

it is difficult to determine how much of the evaporation loss should be apportioned to hydroelectric use since the reservoirs also serve other purposes.

TABLE 6

HYDROELECTRIC PLANTS IN THE YELLOWSTONE BASIN

Name	Water Source	Discharge (af/y)	Generating Capacity (mw)
Mystic	West Rosebud Creek	93,460	10
Yellowtail	Bighorn River	2,531,000	250

FUTURE

Energy Projection Methodology

Energy development in the Yellowstone River Basin in Montana will be affected by many factors, among them:

- 1) the availability of water for energy conversion processes,
- 2) the capacity of the rail system for coal export,
- 3) coal severance taxes,
- 4) the technology and economics of eastern coal desulfurization,
- 5) mined land reclamation requirements,
- 6) federal energy policy,
- 7) international politics,
- 8) federal and state legislation on slurry pipelines,
- 9) the Yellowstone Compact,
- 10) changes in the cost of coal in relation to other energy sources,
- 11) national growth in energy consumption, and
- 12) state policy on the allocation of water to various beneficial uses.

These factors interact in a complex way and are largely unpredictable, making projections of future demand for eastern Montana coal extremely difficult. The approach taken in projecting the energy development levels included here was to attempt to define the upper limit of coal development based on various assumptions regarding the effects of the many factors which will constrain the development. Projections and scenarios from other studies and programs such as the Northern Great Plains Resources Program (NGPRP 1975) were used as a starting point. These levels of development were then modified by incorporating more recent information, including the Montana University Coal Demand Study (Montana University Coal Demand Study Team 1976). Generally the effect of these changes was to reduce the number of gasification plants included in the NGPRP's coal development profiles and to emphasize thermal-electric plants.

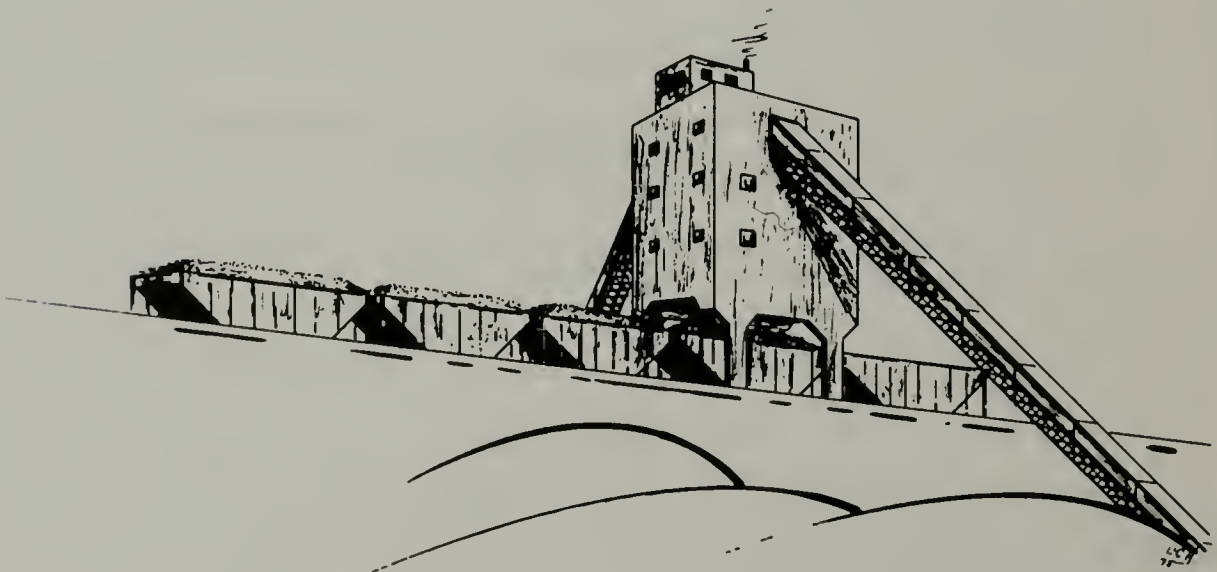
For coal production, the high level of development was based essentially on the NGPRP high projection, while the low level represented existing coal delivery contracts and known plans for new mines, with the intermediate level evenly spaced between the high and low.

The siting of mines and conversion plants was projected in subbasins depending on coal reserves, current mining, coal leases, and applications for industrial water.

It is essential that the state of Montana exert substantial control over the rate and scope of energy development. Thus, each level of development should be examined for its beneficial and adverse impacts so that Montana may, through the legislature, state agencies, and boards, pursue the appropriate energy development future.

Coal Development

In 1975, over 22 million tons of coal were mined in the state, up from 14 million in 1974, 11 million in 1973, and 1 million in 1969. By 1980, even if no new contracts are entered, Montana's annual coal production will exceed 40 million tons. Coal reserves (see "Strippable Coal Reserves" map following page 28), estimated at over 50 billion economically strippable tons (Montana Energy Advisory Council 1976), pose no serious constraint to the levels of development projected by the Yellowstone Impact Study (table 7), which range from 186.7 to 462.8 million tons stripped in the basin annually by the year 2000.



YELLOWSTONE DRAIN MONTANA

STRIPPABLE COAL



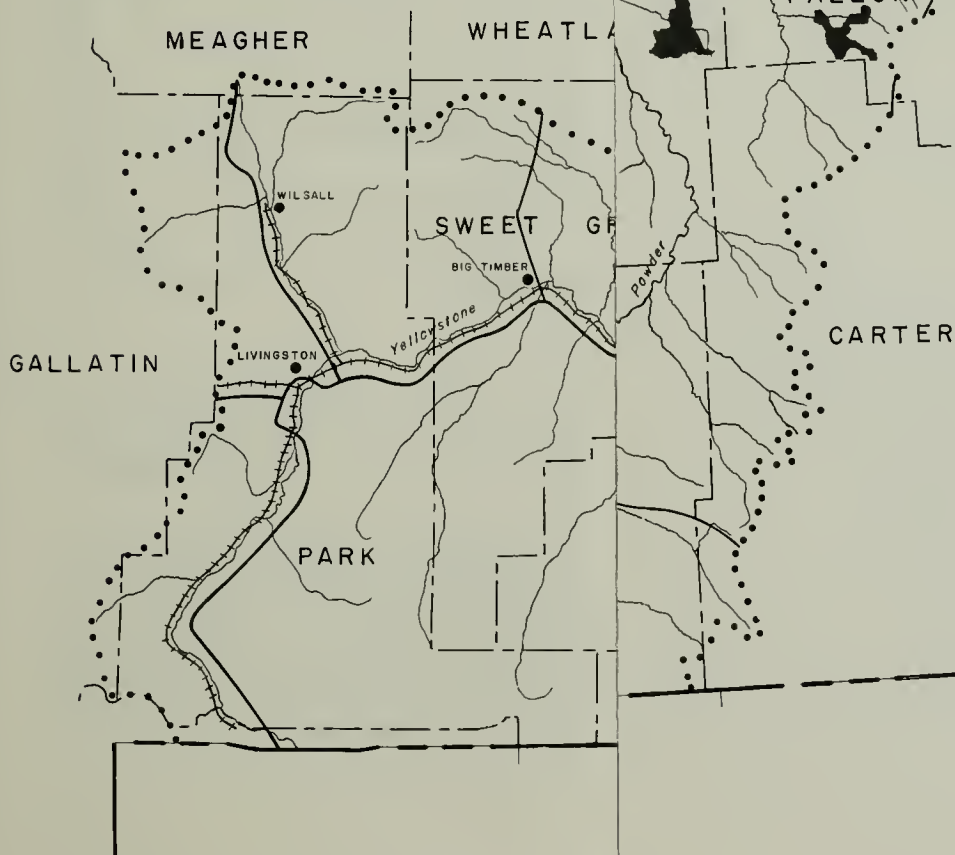
COAL RESERVE

- Drainage Boundary
- ~~~~~ Rivers & Streams
- Roads
- +++++ Railroads
- Towns
- County Lines
- State Lines

10 0 10 20 30 40 MILES

SOURCE:

BUREAU OF MINES AND GEOLOGY,
QUALITY AND RESERVES OF STRIPPABLE
COAL SELECTED DEPOSITS, S.E. MONTANA
December, 1973



STRIPPABLE COAL RESERVES

- Drainage Boundary
- ~~~~~ Rivers & Streams
- Roads
- +++++ Railroads
- Towns
- County Lines
- State Lines



This map illustrates the geographical layout of central and eastern Montana, highlighting county boundaries and the locations of Indian Reservations. The counties depicted are Meagher, Wheatland, Golden Valley, Musselshell, Treasure, Yellowstone, Sweet Grass, Stillwater, Gallatin, Park, Carbon, Crow, Big Horn, Northern Cheyenne Indian Reservation, and Fallon. Major rivers such as the Yellowstone, Snake, Powder, and Rosebud are shown, along with the Yellowstone and Snake River. Indian Reservations shown include the Northern Cheyenne, Crow, and Big Horn. Major cities like Billings, Helena, and Butte are marked. The map also shows the locations of several Indian Reservations, including the Northern Cheyenne, Crow, and Big Horn. The map is titled 'COAST-SELECTED DEPOSIT, S.E. MONTANA' and is dated 'December, 1973'.

TABLE 7

THE PROJECTED USE OF COAL MINED ANNUALLY BY 2000 IN THE YELLOWSTONE BASIN
(MILLIONS OF TONS PER YEAR)

Subbasin ^a	Electric Generation	Gasifi- cation	Syn- crude	Ferti- lizer	Export ^b			Total
					Rail	Slurry	Total	
LOW LEVEL OF DEVELOPMENT								
Bighorn	0	0	0	0	17.1	0	17.1	17.1
Mid-Yellowstone	6.0	7.6	0	0	59.9	0	59.9	73.5
Tongue	2.0	0	0	0	77.0	0	77.0	79.0
Powder	0	0	0	0	17.1	0	17.1	17.1
Lower Yellowstone	0	0	0	0	0	0	0	0
Total	8.0	7.6	0	0	171.1	0	171.1	186.7
INTERMEDIATE LEVEL OF DEVELOPMENT								
Bighorn	0	0	0	0	23.4	5.9	29.3	29.3
Mid-Yellowstone	12.0	7.6	0	0	82.1	20.5	102.6	122.2
Tongue	8.0	0	0	0	105.6	26.4	132.0	140.0
Powder	4.0	0	0	0	23.4	5.9	29.3	33.3
Lower Yellowstone	0	0	0	0	0	0	0	0
Total	24.0	7.6	0	0	234.5	58.7	293.2	324.8
HIGH LEVEL OF DEVELOPMENT								
Bighorn	4.0	0	0	0	22.1	14.8	36.9	40.9
Mid-Yellowstone	12.0	15.2	18.0	0	77.3	51.6	128.9	174.1
Tongue	12.0	7.6	18.0	0	99.5	66.3	165.8	203.4
Powder	4.0	0	0	0	22.1	14.8	36.9	40.9
Lower Yellowstone	0	0	0	3.5	0	0	0	3.5
Total	32.0	22.8	36.0	3.5	221.0	147.5	368.5	462.8

^a The four subbasins not shown (Upper Yellowstone, Billings Area, Clarks Fork Yellowstone, and Kinsey Area) do not include economically strippable coal deposits.

^b It is assumed that, at the intermediate level of development, 20% of coal exports will be by slurry pipeline, and at the high level of development, 40%.

The Yellowstone Impact Study projections for coal conversion are shown in table 8 and the related water requirement illustrated in table 9. Unit water requirements used to derive water use from coal mining and conversion projections are shown in appendix A.

The "Potential Reservoir Sites and Major Industrial Water Applications" map following page 29 locates: 1) filings for industrial purposes made prior to passage in 1973 of the Montana Water Use Act, and 2) major applications for industrial purposes made following passage of the Act. The amounts of water filed or applied for are shown in detail in appendix B. Industrial companies have applied for much more water than will be required even assuming the highest projected level of coal development. In fact, they have applied

TABLE 7

THE PROJECTED USE OF COAL MINED ANNUALLY BY 2000 IN THE YELLOWSTONE BASIN
(MILLIONS OF TONS PER YEAR)

Subbasin ^a	Electric Generation	Gasifi- cation	Syn- crude	Ferti- lizer	Export ^b			Total
					Rail	Slurry	Total	
LOW LEVEL OF DEVELOPMENT								
Bighorn	0	0	0	0	17.1	0	17.1	17.1
Mid-Yellowstone	6.0	7.6	0	0	59.9	0	59.9	73.5
Tongue	2.0	0	0	0	77.0	0	77.0	79.0
Powder	0	0	0	0	17.1	0	17.1	17.1
Lower Yellowstone	0	0	0	0	0	0	0	0
Total	8.0	7.6	0	0	171.1	0	171.1	186.7
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^a The four subbasins not shown (Upper Yellowstone, Billings Area, Clarks Fork Yellowstone, and Kinsey Area) do not include economically strippable coal deposits.

^b It is assumed that, at the intermediate level of development, 20% of coal exports will be by slurry pipeline, and at the high level of development, 40%.

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MAJOR INVESTIGATOR AND/OR INDUSTRIAL APPLICANT	RESERVOIR	CAPACITY (acre-feet)
● Basin Electric	*	
Bureau of Reclamation	1 Allenspur	4,000,000
	2 Beehive	300,000
	6 Buffalo Creek	73,000
	10 Cedar Ridge	127,000
	8 Custer	825,000
	7 Lissa	2,180,000
	21 Moon Creek	150,000
	15 Moorhead	1,150,000
	25 Sunday Creek	678,000
	17 Sweeney Creek	116,000
	9 Tullock	270,000
Crow Tribe	11 Little Bighorn	70,000
	13 Owl Creek	8,000
	12 Pass Creek	14,000
	5 Pryor Creek	22,000
○ Getty Oil Co.	26 Thirteenmile Creek	32,000
+ ▢ Gulf Mineral Resources Co.	23 Coal Creek	29,480
	22 Lignite Creek	50,870
	20 Mizpah Creek	104,025
	18 Pump Creek	48,440
	19 Pumpkin Creek	103,410
⊗ Hunt Oil	*	
■ Intake Water Co.	**	
○ Mobil Oil Corporation	***	
Montana Department of Natural Resources and Conservation	14 New Tongue River	450,000
+ ▴ Montana Power Co. (3 filings)	*	
▢ Montana Water Storage Co.	16 Lay Creek	130,000
Soil Conservation Service	4 Bluewater Creek	12,000
	3 Elbow Creek	11,700
... ▴ Utah International Inc.	+	
● Water Reserve Co.	24 Squaw Creek	91,000

NOTE: The linear symbols in red (+--, +---, ..., ...) that precede the red location symbols for three of the applicant companies above represent the water conveyance systems (pipelines, canals, and drops) associated with those applications.

*These are filings submitted prior to the 1973 Water Use Act. No reservoirs are associated with them.

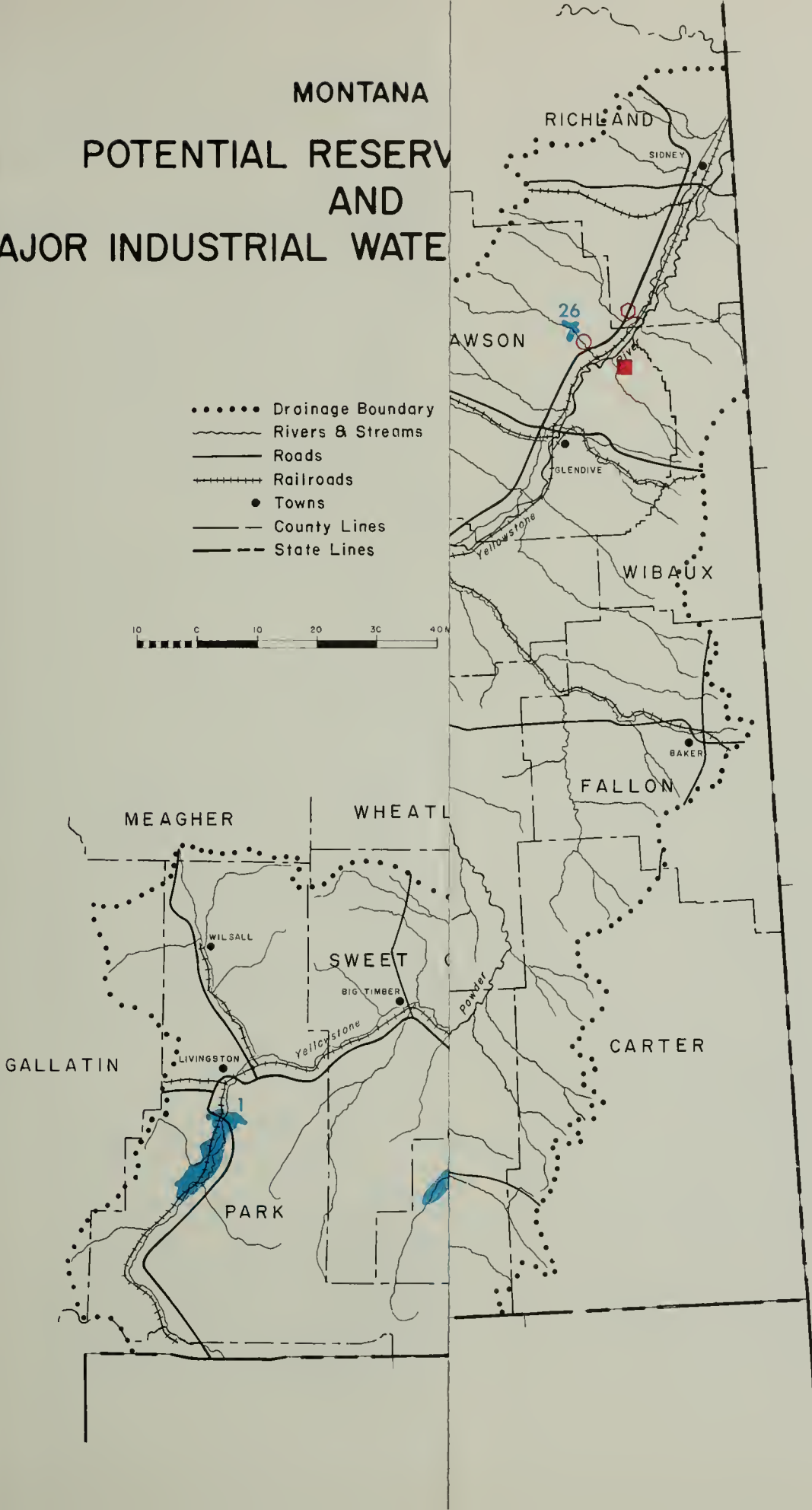
**Intake Water Company investigated a smaller reservoir (564,400 acre-foot capacity) at the Moorhead site (15). Intake also filed prior to the Water Use Act for use of 111 cfs from the lower Yellowstone (see map); that filing is under litigation.

***Mobil Oil Corporation investigated a larger reservoir (50,000 acre-foot capacity) at the Thirteenmile site (26).

+Utah International Inc. investigated a reservoir site (106,730 acre-foot capacity) on Fence Creek in Wyoming, intending use of that water in Montana.

MONTANA POTENTIAL RESERV AND MAJOR INDUSTRIAL WATE

- Drainage Boundary
- ~~~~~ Rivers & Streams
- Roads
- + + + + + Railroads
- Towns
- County Lines
- - - - - State Lines



MONTANA

POTENTIAL RESERVOIR SITES AND

MAJOR INDUSTRIAL WATER APPLICATIONS

- Drainage Boundary
- ~~~~~ Rivers & Streams
- Roads
- +—— Railroads
- Towns
- County Lines
- State Lines

10 20 30 40 MILES

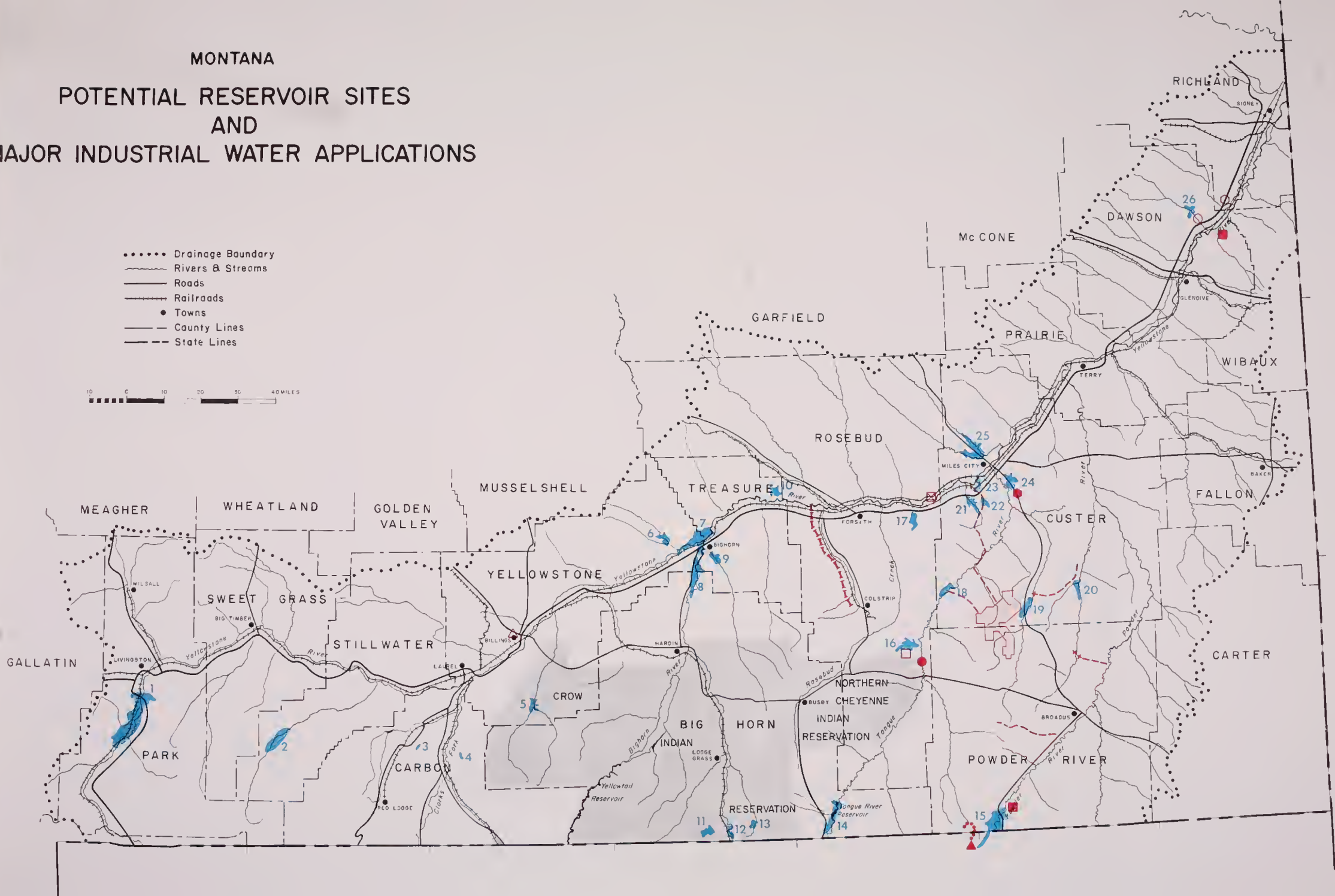


TABLE 8

THE INCREASE IN COAL CONVERSION IN THE YELLOWSTONE
BASIN BY THE YEAR 2000

Subbasin ^a	Electric Generation (mw)	SNG (mmcf/d)	Syncrude (b/d)	Fertilizer (t/d)
LOW LEVEL OF DEVELOPMENT				
Bighorn	0	0	0	0
Mid-Yellowstone	1,500	250	0	0
Tongue	500	0	0	0
Powder	0	0	0	0
Lower Yellowstone	0	0	0	0
Total	2,000	250	0	0
INTERMEDIATE LEVEL OF DEVELOPMENT				
Bighorn	0	0	0	0
Mid-Yellowstone	3,000	250	0	0
Tongue	2,000	0	0	0
Powder	1,000	0	0	0
Lower Yellowstone	0	0	0	0
Total	6,000	250	0	0
HIGH LEVEL OF DEVELOPMENT				
Bighorn	1,000	0	0	0
Mid-Yellowstone	3,000	500	100,000	0
Tongue	3,000	250	100,000	0
Powder	1,000	0	0	0
Lower Yellowstone	0	0	0	2,300
Total	8,000	750	200,000	2,300

^a The four subbasins not listed (Upper Yellowstone, Billings Area, Clarks Fork Yellowstone, and Kinsey Area) are not expected to include sites for coal conversion facilities.

in the Tongue and Powder river basins for more than is available, even through maximum storage.

Also shown on the "Potential Reservoir Sites and Major Industrial Water Applications" map are 26 potential reservoir sites investigated by energy companies in connection with their applications and filings and by federal and state agencies. For a variety of environmental and economic reasons, most of these sites will probably never be developed. The Allenspur site, for instance, was the subject of a joint resolution passed by the Montana legislature in 1974 declaring that construction of the dam would be contrary to state goals and objectives.

TABLE 8

THE INCREASE IN COAL CONVERSION IN THE YELLOWSTONE
BASIN BY THE YEAR 2000

Subbasin ^a	Electric Generation (mw)	SNG (mmcf/d)	Syncrude (b/d)	Fertilizer (t/d)
LOW LEVEL OF DEVELOPMENT				
Bighorn	0	0	0	0
Mid-Yellowstone	1,500	250	0	0
Tongue	500	0	0	0
Powder	0	0	0	0
Lower Yellowstone	0	0	0	0
Total	2,000	250	0	0
INTERMEDIATE LEVEL OF DEVELOPMENT				
Bighorn	0	0	0	0
Mid-Yellowstone	3,000	250	0	0
Tongue	2,000	0	0	0
Powder	1,000	0	0	0
Lower Yellowstone	0	0	0	0
Total	6,000	250	0	0
HIGH LEVEL OF DEVELOPMENT				
Bighorn	1,000	0	0	0
Mid-Yellowstone	3,000	500	100,000	0
Tongue	3,000	250	100,000	0
Powder	1,000	0	0	0
Lower Yellowstone	0	0	0	2,300
Total	8,000	750	200,000	2,300

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TABLE 9

THE INCREASE IN WATER DEPLETION FOR ENERGY BY THE YEAR 2000
BY SUBBASIN (af/y)

Subbasin*	INCREASE IN DEPLETION (af/y)						Total
	Elec. Generation	Gasifi- cation	Syn- crude	Ferti- lizer	Export	Strip Mining	
LOW LEVEL OF DEVELOPMENT							
Bighorn	0	0	0	0	0	860	860
Mid-Yellowstone	22,500	9,000	0	0	0	3,680	35,180
Tongue	7,500	0	0	0	0	3,950	11,450
Powder	0	0	0	0	0	860	860
Lower Yellowstone	0	0	0	0	0	0	0
Total	30,000	9,000				9,350	48,350
INTERMEDIATE LEVEL OF DEVELOPMENT							
Bighorn	0	0	0	0	4,420	1,470	5,890
Mid-Yellowstone	45,000	9,000	0	0	15,380	6,110	75,490
Tongue	30,000	0	0	0	9,900	7,000	46,900
Powder	15,000	0	0	0	2,210	1,670	18,880
Lower Yellowstone	0	0	0	0	0	0	0
Total	90,000	9,000			31,910	16,250	147,160
HIGH LEVEL OF DEVELOPMENT							
Bighorn	15,000	0	0	0	11,100	2,050	28,150
Mid-Yellowstone	45,000	18,000	29,000	0	38,700	8,710	139,410
Tongue	45,000	9,000	29,000	0	24,860	10,170	118,030
Powder	15,000	0	0	0	11,100	2,050	28,150
Lower Yellowstone	0	0	0	13,000	0	0	13,000
Total	120,000	27,000	58,000	13,000	80,210	22,980	326,740

* The four subbasins not shown (Upper Yellowstone, Billings Area, Clarks Fork Yellowstone, and Kinsey Area), are not expected to experience water depletion associated with coal development.

Hydroelectric Generation Potential

The potential for hydroelectric power generation in the basin is comparatively small. Even though the "Potential Reservoir Sites and Major Industrial Water Applications" map shows many reservoir sites, only the Allenspur and Lissa sites have been evaluated for hydroelectric potential; the Allenspur dam, if built, could provide 250 mw of power, and the Lissa dam, 85 mw.

WATER USE FOR IRRIGATED AGRICULTURE

PRESENT

Rainfall during the growing season, particularly in the eastern portion of the basin, rarely exceeds 10 inches. Since water requirements for most irrigated crops are normally over 20 inches during the entire growing season, irrigation of many crops is necessary. Lands in the basin which are now either fully or partially irrigated total about 650,000 acres and consume annually about 1.5 mmf of water. This acreage figure is slightly higher than the 630,235 acres listed in the legend of the "Irrigated and Irrigable Lands" map following page 33. The higher figure is the most recent and includes information not available when the lower figure was calculated.

Irrigated agriculture in the Yellowstone Basin has been increasing since 1971 (Montana DNRC 1975b). Much of this expansion can be attributed to the introduction of sprinkler irrigation systems. Results from a questionnaire sent to local Soil Conservation Service offices indicate that approximately two-thirds of all irrigation systems recently installed are sprinkler systems (Montana DNRC 1975b), with pump lifts varying from a few feet to 450 feet.

FUTURE

Most irrigated agricultural products are used in beef production, which is highly variable. The future of irrigation depends, therefore, on more than availability of our land and water resources. General economic conditions, federal import and export policies, farmer preference, and world eating habits will be influential.

Irrigation Feasibility

The DNRC is conducting studies to determine the feasibility of delivering water to irrigable lands in the Yellowstone Basin, and to project what development may occur in the next 25 years. Only the Yellowstone River and the four main tributaries (Clarks Fork, Bighorn, Tongue, and Powder) were considered as water sources for future development.

DNRC's reconnaissance land classification survey was used to identify the irrigable land in the basin. A preliminary economic evaluation, conducted to set upper limits of pumping feasibility, limited the area of consideration to land no more than three miles from the river and no more than 450 feet above the water source. The total area considered was thus reduced from the 2.2 million irrigable acres listed in the land classification survey to 448,000 acres, which were categorized according to lift (50' increments) and pipeline length (half-mile increments). The study concluded that of the 448,000 acres studied, 237,000 are financially feasible for irrigation given the assumptions and constraints explained in appendix C. The 237,000 acres feasible for irrigation are identified by county in the legend of the "Irrigated and Irrigable Lands" map following page 33. Table 10 shows the feasibly irrigable acreage in each subbasin by lift and pipeline length, and table 11 shows the same acreage by subbasin and county.

COUNTY	IRRIGATED LANDS 	IRRIGABLE LANDS 	LANDS FEASIBLE TO IRRIGATE * (not shown on map)
Big Horn	73,724	309,676	15,222
Carbon	96,363	70,509	2,160
Carter	2,185	12,108	**
Custer	42,244	88,272	43,795
Dawson	19,475	416,902	18,355
Fallon	2,433	48,399	**
Gallatin	4,220	4,180	**
Garfield	80	0	**
McCone	0	498	**
Meagher	25	121	**
Musselshell	102	674	**
Park	63,937	98,249	21,664
Powder River	33,339	394,486	46,853
Prairie	13,048	77,895	11,789
Richland	38,333	113,057	10,421
Rosebud	32,271	126,507	21,135
Stillwater	34,721	18,930	10,204
Sweetgrass	55,586	88,805	6,208
Treasure	21,231	82,504	9,591
Wibaux	107	18,489	663
Yellowstone	96,811	232,126	19,412
Basin total	630,235	2,202,387	237,472

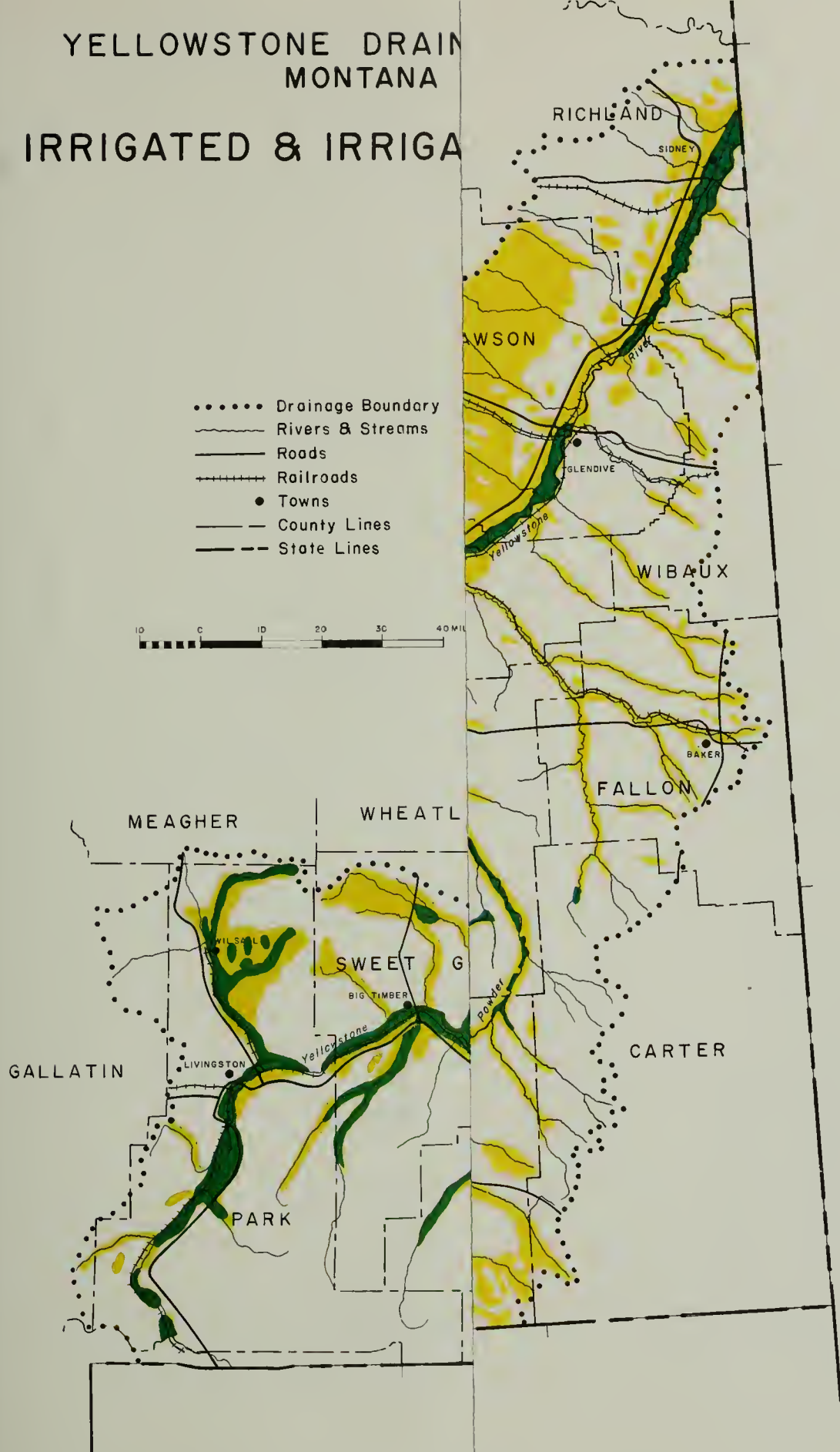
*Criteria for feasibility are explained elsewhere in this report.

**Because only the Yellowstone mainstem and its major tributaries were considered as sources of irrigation water in the feasibility study discussed in this report, no lands in these counties were considered economically feasible to irrigate.

YELLOWSTONE DRAIN MONTANA

IRRIGATED & IRRIGA

- Drainage Boundary
- ~~~~~ Rivers & Streams
- Roads
- + + + + + Railroads
- Towns
- County Lines
- - - - - State Lines



YELLOWSTONE DRAINAGE BASIN MONTANA

IRRIGATED & IRRIGABLE LANDS

- Drainage Boundary
- ~~~~~ Rivers & Streams
- Roads
- +—— Railroads
- Towns
- County Lines
- State Lines

0 10 20 30 40 MILES

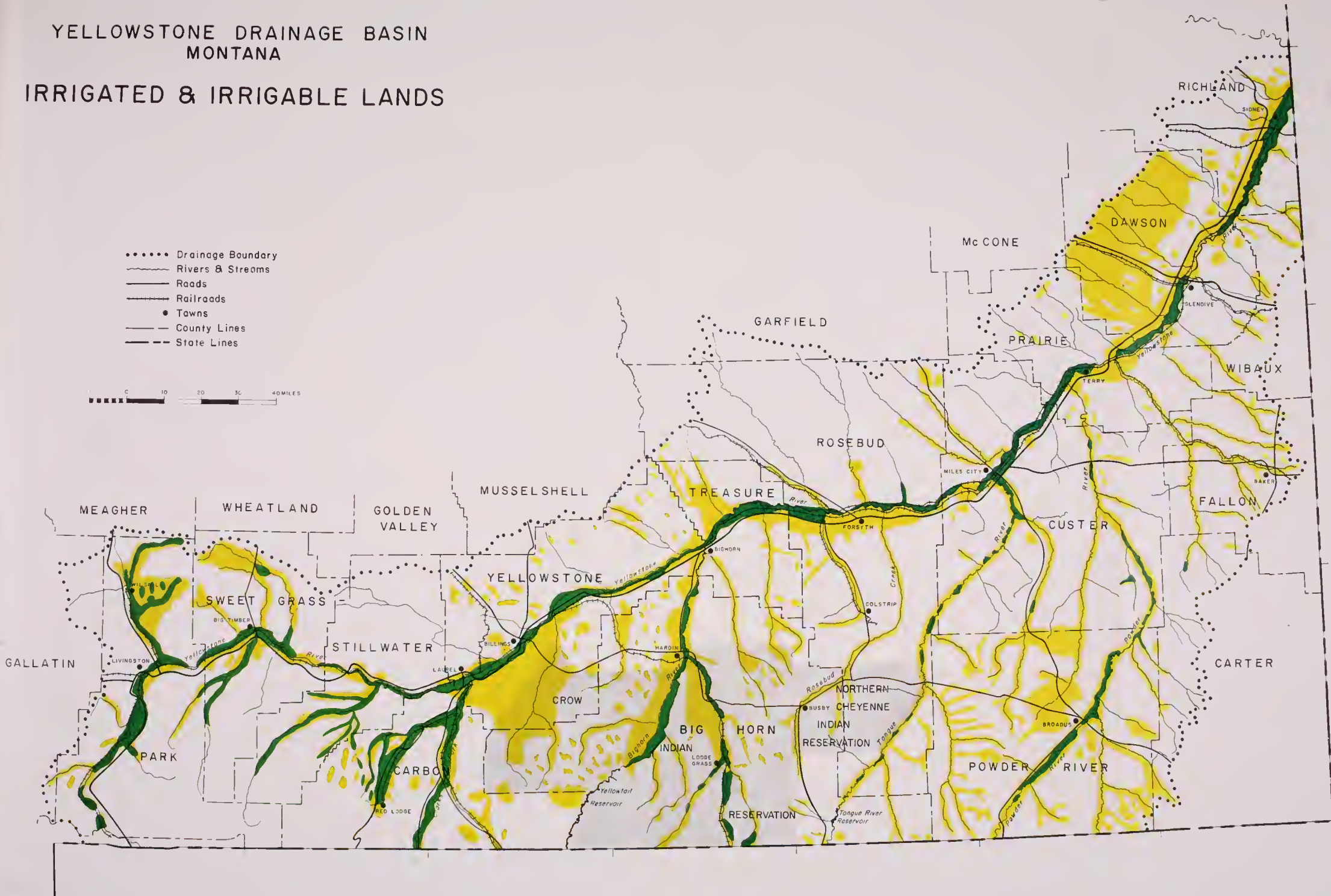


TABLE 10
FEASIBLY IRRIGABLE ACREAGE BY LIFT AND PIPELINE LENGTH,
HIGH LEVEL OF DEVELOPMENT

HIGH LEVEL OF DEVELOPMENT							
Pipeline length (mi)	Lift (ft)						Total
	0-50	50-100	100-150	150-200	200-250	250-300	
UPPER YELLOWSTONE SUBBASIN							
0 - .5	38,076	0	0	0	0	0	38,076
CLARKS FORK SUBBASIN							
0 - .5	2,160	0	0	0	0	0	2,160
BILLINGS AREA SUBBASIN							
0 - .5	3,308	3,324	329	2,147	0	222	9,330
.5 - 1.0	347	71	8,084	1,305	0	0	9,807
1.0 - 1.5	110	0	0	0	0	0	110
1.5 - 2.0	0	165	0	0	0	0	165
Total	3,765	3,560	8,413	3,452	0	222	19,412
BIGHORN SUBBASIN							
0 - .5	4,478	0	1,309	0	0	0	5,787
.5 - 1.0	1,608	3,451	0	0	0	0	5,059
1.0 - 1.5	0	2,191	0	0	0	0	2,191
Total	6,086	5,642	1,309	0	0	0	13,037
MID-YELLOWSTONE SUBBASIN							
0 - .5	16,000	1,691	0	0	0	0	17,691
.5 - 1.0	3,180	4,358	0	0	0	0	7,538
Total	19,180	6,049	0	0	0	0	25,229
TONGUE SUBBASIN							
0 - .5	21,947	0	0	0	0	0	21,947
KINSEY AREA SUBBASIN							
0 - .5	3,248	0	0	1,180	0	0	4,428
.5 - 1.0	0	0	0	0	0	0	0
1.0 - 1.5	308	0	0	0	0	0	308
Total	3,556	0	0	1,180	0	0	4,736
POWDER RIVER SUBBASIN							
0 - .5	74,224	0	0	0	0	0	74,224
.5 - 1.0	981	0	0	0	0	0	981
Total	75,205	0	0	0	0	0	75,205
LOWER YELLOWSTONE SUBBASIN							
0 - .5	23,677	1,804	1,775	0	0	0	27,256
.5 - 1.0	1,813	4,992	100	0	0	0	6,905
1.0 - 1.5	0	2,599	0	0	0	0	2,599
1.5 - 2.0	0	805	0	0	0	0	805
2.0 - 2.5	0	105	0	0	0	0	105
Total	25,490	10,305	1,875	0	0	0	37,670
BASIN SUMMARY							
0 - .5	187,118	6,819	3,413	3,327	0	222	200,899
.5 - 1.0	7,929	12,872	8,184	1,305	0	0	30,290
1.0 - 1.5	418	4,790	0	0	0	0	5,208
1.5 - 2.0	0	970	0	0	0	0	970
2.0 - 2.5	0	105	0	0	0	0	105
Total	195,465	25,556	11,597	4,632	0	222	237,472

NOTE: This table should not be considered an exhaustive listing of all feasibly irrigable acreage in the Yellowstone Basin; it includes only the acreage identified as feasibly irrigable according to the geographic and economic constraints explained elsewhere in this report.

TABLE 10
FEASIBLY IRRIGABLE ACREAGE BY LIFT AND PIPELINE LENGTH,
HIGH LEVEL OF DEVELOPMENT

HIGH LEVEL OF DEVELOPMENT							
Pipeline length (mi)	Lift (ft)						Total
	0-50	50-100	100-150	150-200	200-250	250-300	
UPPER YELLOWSTONE SUBBASIN							
0 - .5	38,076	0	0	0	0	0	38,076
CLARKS FORK SUBBASIN							
0 - .5	2,160	0	0	0	0	0	2,160
BILLINGS AREA SUBBASIN							
0 - .5	3,308	3,324	329	2,147	0	222	9,330
.5 - 1.0	347	71	8,084	1,305	0	0	9,807
1.0 - 1.5	110	0	0	0	0	0	110
1.5 - 2.0	0	165	0	0	0	0	165
Total	3,765	3,560	8,413	3,452	0	222	19,412
BIGHORN SUBBASIN							
0 - .5	4,478	0	1,309	0	0	0	5,787
.5 - 1.0	1,608	3,451	0	0	0	0	5,059
1.0 - 1.5	0	2,191	0	0	0	0	2,191
Total	6,086	5,642	1,309	0	0	0	13,037
MID-YELLOWSTONE SUBBASIN							
0 - .5	16,000	1,691	0	0	0	0	17,691
.5 - 1.0	3,180	4,358	0	0	0	0	7,538
Total	19,180	6,049	0	0	0	0	25,229
TONGUE SUBBASIN							
0 - .5	21,947	0	0	0	0	0	21,947
KINSEY AREA SUBBASIN							
0 - .5	3,248	0	0	1,180	0	0	4,428
.5 - 1.0	0	0	0	0	0	0	0
1.0 - 1.5	308	0	0	0	0	0	308
Total	3,556	0	0	1,180	0	0	4,736
POWDER RIVER SUBBASIN							
0 - .5	74,224	0	0	0	0	0	74,224
.5 - 1.0	981	0	0	0	0	0	981
Total	75,205	0	0	0	0	0	75,205
LOWER YELLOWSTONE SUBBASIN							
0 - .5	23,677	1,804	1,775	0	0	0	27,256
.5 - 1.0	1,813	4,992	100	0	0	0	6,905
1.0 - 1.5	0	2,599	0	0	0	0	2,599
1.5 - 2.0	0	805	0	0	0	0	805
2.0 - 2.5	0	105	0	0	0	0	105
Total	25,490	10,305	1,875	0	0	0	37,670
BASIN SUMMARY							
0 - .5	187,118	6,819	3,413	3,327	0	222	200,899
.5 - 1.0	7,929	12,872	8,184	1,305	0	0	30,290
1.0 - 1.5	418	4,790	0	0	0	0	5,208
1.5 - 2.0	0	970	0	0	0	0	970
2.0 - 2.5	0	105	0	0	0	0	105
Total	195,465	25,556	11,597	4,632	0	222	237,472

NOTE: This table should not be considered an exhaustive listing of all feasibly irrigable acreage in the Yellowstone Basin; it includes only the acreage identified as feasibly irrigable according to the geographic and economic constraints explained elsewhere in this report.

TABLE 11

FEASIBLY IRRIGABLE ACREAGE BY COUNTY AND SUBBASIN BY 2000, HIGH LEVEL OF DEVELOPMENT

County	Upper Yellowstone	Clarks Fork	Billings Area	Big Horn	Mid Yellowstone	Tongue River	Kinsey Area	Powder River	Lower Yellowstone	County Totals
Park	21,664									21,664
Sweet Grass	6,208									6,208
Stillwater	10,204									10,204
Carbon		2,160								2,160
Yellowstone			19,412							19,412
Big Horn				13,037		2,185				15,222
Treasure					9,591					9,591
Rosebud					11,408	9,727				21,135
Powder								46,853		46,853
River								26,438		43,795
Custer					4,230	10,035	3,092	1,914	8,231	11,789
Prairie							1,644		18,355	18,355
Dawson									10,421	10,421
Richland									633	633
Wibaux										
Basin Totals	38,076	2,160	19,412	13,037	25,229	21,947	4,736	75,205	37,670	237,472

NOTE: The number of irrigable acres for the low and intermediate development levels are one-third and two-thirds, respectively, of the numbers given here. This table should not be considered an exhaustive listing of all feasibly irrigable acreage in the Yellowstone Basin; it includes only the acreage identified as feasibly irrigable according to the geographic and economic constraints explained elsewhere in this report.

Three levels of development were projected to allow for such factors as farmer preference and peer influence: the lowest includes one-third, the intermediate, two-thirds, and the highest, all of the feasibly irrigable acreage. These constant-interval levels permit interpolation of results to other possible situations.

The number of acres financially feasible for irrigation for each development level was converted to a projected water consumption by applying a water depletion rate of two acre-feet per acre. This rate was derived from average consumption requirements for basin crops with allowances for factors such as evaporation and leakage from distribution systems. Table 12 shows the increased irrigated acreage and associated water consumption for the low, medium, and high levels of development in each subbasin.

MUNICIPAL WATER USE

In 1970, 81 percent of the Yellowstone Basin's 168,300 people were served by municipal systems which used 29.4 mgd (32,900 af/y) of surface and ground water. Even if all of that diverted amount were consumed, it would not be a significant depletion compared to the 1.5 mmf/y currently consumed by irrigated agriculture in the basin.

The basin's projected population increase and associated municipal water use depletion for each level of development are shown in table 13. Even the 10,620 af/y depletion increase by 2000 shown for the highest development level is not significant compared to the projected depletion increases for irrigation or coal development. Nor is any problem anticipated

TABLE 12

THE INCREASE IN WATER DEPLETION FOR
IRRIGATED AGRICULTURE BY 2000
BY SUBBASIN

Subbasin	Acreage Increase	Increase in Depletion (af/y)
HIGH LEVEL OF DEVELOPMENT		
Upper Yellowstone	38,080	76,160
Clarks Fork	2,160	4,320
Billings Area	19,410	38,820
Bighorn	13,040	26,080
Mid-Yellowstone	25,230	50,460
Tongue	21,950	43,900
Kinsey Area	4,740	9,480
Powder	75,200	150,400
Lower Yellowstone	37,670	75,340
TOTAL	237,480	474,960
INTERMEDIATE LEVEL OF DEVELOPMENT		
BASIN TOTAL	158,320	316,640
LOW LEVEL OF DEVELOPMENT		
BASIN TOTAL	79,160	158,320

NOTE: The numbers of irrigated acres at the low and intermediate levels of development are not shown by subbasin; however, those numbers are one-third and two-thirds, respectively, of the acres shown for each subbasin at the high level of development.

in the availability of water to satisfy this increased municipal use. Many municipalities in the Yellowstone Basin utilize ground water and would presumably not experience shortages with any of the three development levels. Those using surface waters would likewise not experience shortages, since they are located high in the basin where there would be no energy diversions or on the mainstem where the supply is adequate. It is likely, however, that any municipal system serving an area which experiences a significant

population increase would need to expand by providing new wells or pumps and constructing new storage, treatment, and distribution systems.

TABLE 13

THE INCREASE IN WATER DEPLETION FOR MUNICIPAL USE BY 2000

Level of Development	Population Increase	Increase in Depletion (af/y)
Low	56,858	5,880
Intermediate	62,940	6,960
High	94,150	10,620

Appendix D shows present and projected municipal water use by subbasin and details projected population increases in the basin.

OTHER CONSUMPTIVE WATER USES

There are a number of other consumptive water uses in Montana, including rural domestic, livestock, and nonenergy industrial uses. While these uses are vital, they consume only a small amount of water now and are not expected to require a significant amount of water at any time in the near future. Further information concerning these water uses can be found in Water Use in Montana, a report published as part of the State Water Plan (Montana DNRC 1975a).

WATER AVAILABILITY FOR PROJECTED CONSUMPTIVE USE

The average annual yield of the Yellowstone River Basin, at the 1970 level of development, is 8.8 mmcf. As shown in table 14, the additional annual depletions required for the high level of development total about 812,000 acre-feet. Comparison of these two numbers might lead to the conclusion that there is ample water for such development, and more. That conclusion would be erroneous, however, because of the extreme variation of Yellowstone Basin streamflows from year to year, from month to month, and from place to place. At certain places and at certain times the water supply will be adequate in the foreseeable future. But in some of the tributaries and during low-flow times of many years, water availability problems, even under the low level of development, will be very real and sometimes very serious. In planning for additional agricultural or industrial developments, it is essential to know how much water is dependable for use, year after year.

This problem was addressed using the Montana State Water Planning Model, a computerized technique of simulating the monthly outflows from the nine planning subbasins. The model reports the monthly flow that the subbasin would have produced had each projected level of development been

TABLE 14

THE INCREASE IN WATER DEPLETION FOR CONSUMPTIVE USE
BY 2000, BY SUBBASIN

Subbasin	Increase in Depletion (af/y)			
	Irrigation	Energy	Municipal	Total
LOW LEVEL OF DEVELOPMENT				
Upper Yellowstone	25,380	0	0	25,380
Clarks Fork	1,440	0	0	1,440
Billings Area	12,940	0	3,480	16,420
Bighorn	8,700	860	negligible	9,560
Mid-Yellowstone	16,820	35,180	1,680	53,680
Tongue	14,640	11,450	negligible	26,090
Kinsey Area	3,160	0	0	3,160
Powder	50,140	860	360	51,360
Lower Yellowstone	25,120	0	360	25,480
TOTAL	158,340	48,350	5,880	212,570
INTERMEDIATE LEVEL OF DEVELOPMENT				
Upper Yellowstone	50,780	0	0	50,780
Clarks Fork	2,880	0	0	2,880
Billings Area	25,880	0	3,540	29,420
Bighorn	17,380	5,890	300	23,570
Mid-Yellowstone	33,640	75,490	1,860	110,990
Tongue	29,260	46,900	300	76,460
Kinsey Area	6,320	0	0	6,320
Powder	100,280	18,880	600	119,760
Lower Yellowstone	50,200	0	360	50,560
TOTAL	316,620	147,160	6,960	470,740
HIGH LEVEL OF DEVELOPMENT				
Upper Yellowstone	76,160	0	0	76,160
Clarks Fork	4,320	0	0	4,320
Billings Area	38,820	0	3,900	42,720
Bighorn	26,080	28,150	480	54,710
Mid-Yellowstone	50,460	139,410	3,840	193,710
Tongue	43,900	118,030	780	162,710
Kinsey Area	9,480	0	0	9,480
Powder	150,400	28,150	1,140	179,690
Lower Yellowstone	75,340	13,000	480	88,820
TOTAL	474,960	326,740	10,620	812,320

in effect during the previous years for which streamflow data are available.

A shortcoming of this procedure is that it cannot account for the allocation of waters to Montana and Wyoming under the terms of the Yellowstone

Compact. It must be recognized that, especially for the Tongue and Powder subbasins, water that is shown to be hydrologically available in Montana may not be legally available once the issues surrounding the compact are resolved. In the absence of resolution of the compact issues, the Department's analysis assumed that water development in Wyoming would consume less water than Wyoming's compact share. The projections published in the Wyoming State Water Plan were assumed to be the best estimate of this water use.

Because the Yellowstone Impact Study focused on the middle and lower portions of the basin, little is presented here and in other sections of this report with respect to the Clarks Fork Yellowstone and the Upper Yellowstone subbasins. However, because the projected agricultural and energy development is predominantly in the middle and lower portions of the basin, water availability problems and associated impacts (see Part III) in these upper subbasins are expected to be slight.

TONGUE RIVER

Tongue River Reservoir, constructed in 1939, has an active storage of about 69,000 acre-feet and firm annual yield of 40,000 acre-feet, all of which is now obligated. There can be essentially no further development in the basin unless additional storage is provided.

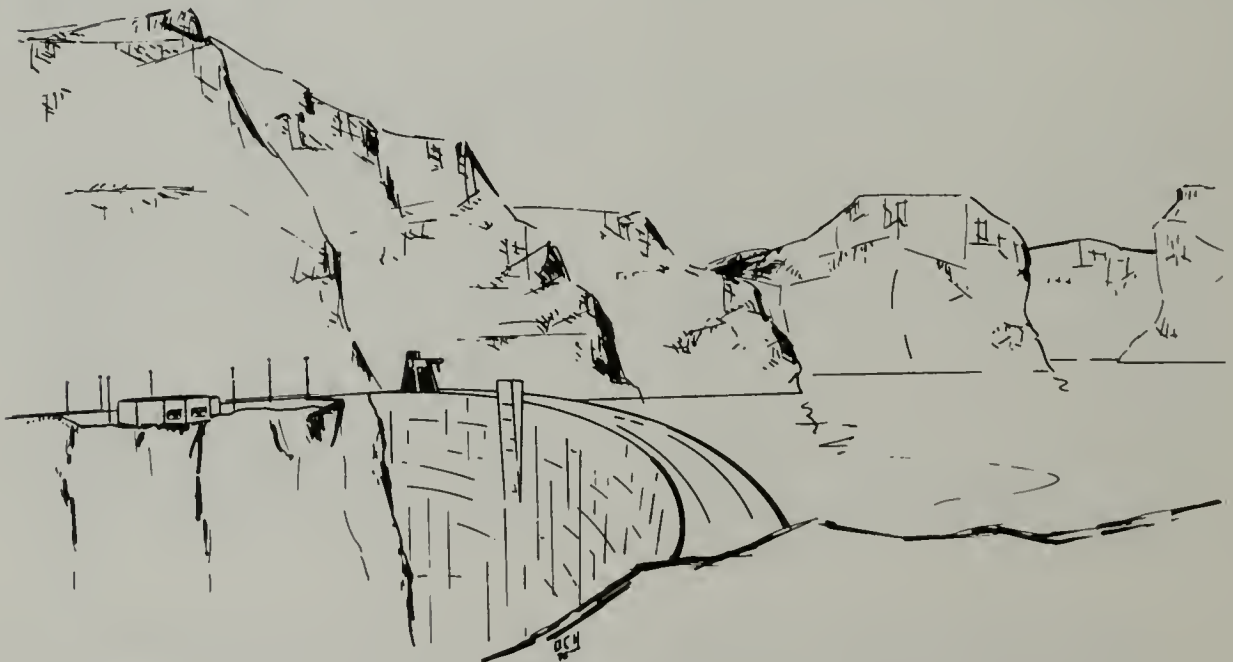
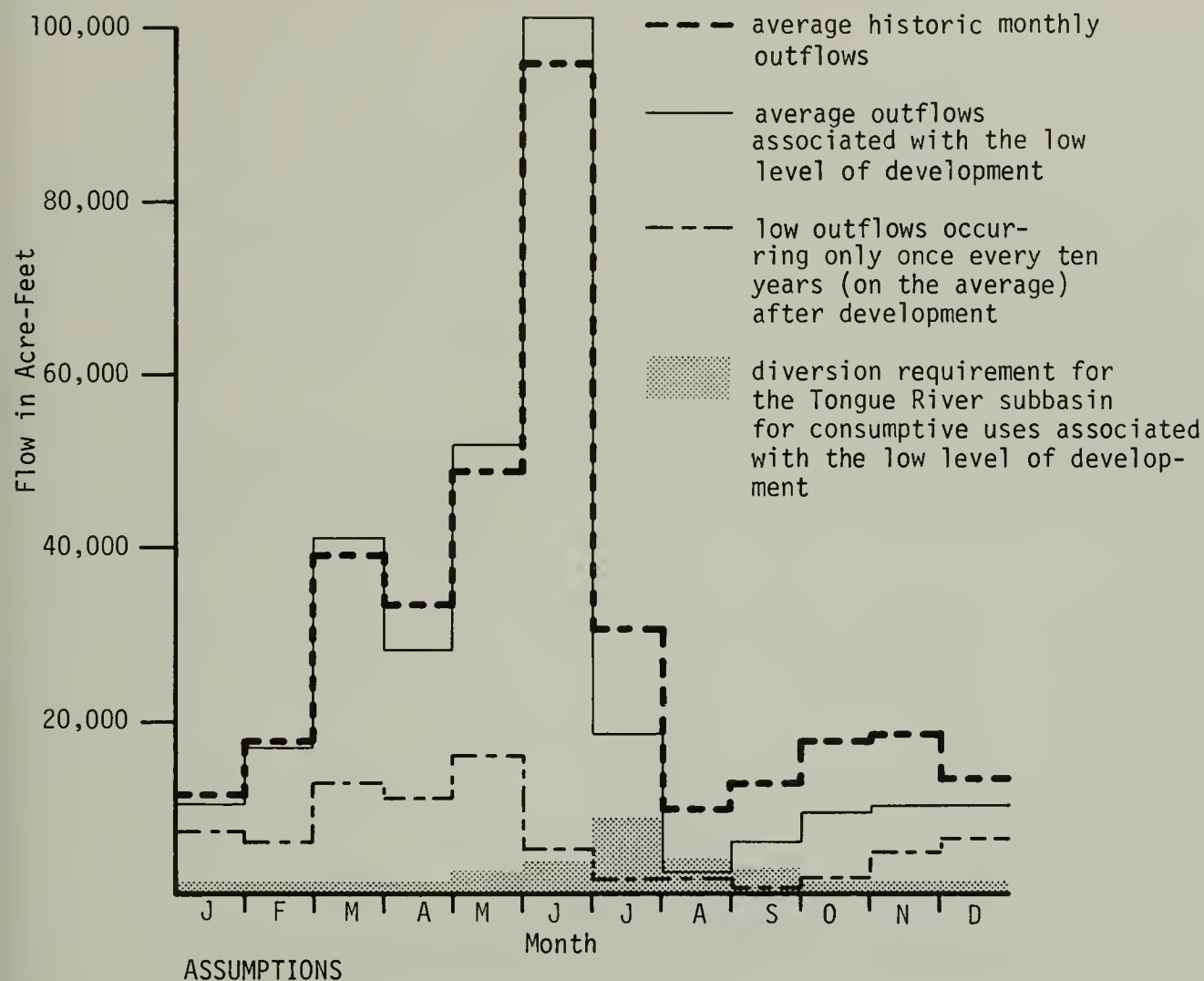


Figure 3 shows a monthly hydrograph of outflows from the Tongue River Basin for the low level of development. Raising the existing dam to increase the active storage by 56,000 acre-feet would provide a total firm annual yield of about 73,000 acre-feet, which includes the 40,000 acre-feet currently contracted and used. This larger reservoir would also provide modest instream flows.

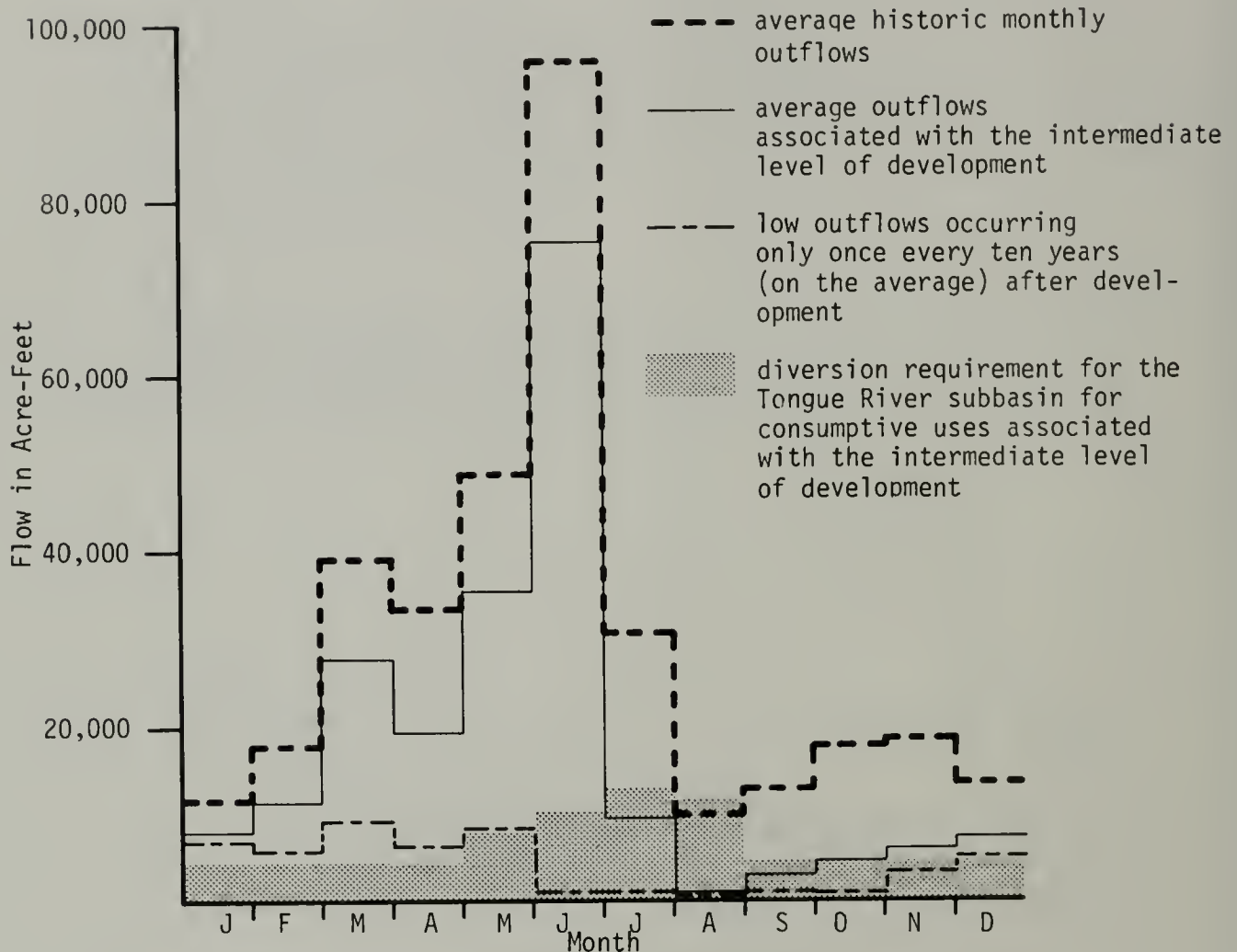


Level of development: all of the projected low level of development
 Reservoir active storage: 125,000 af
 Subbasin firm annual yield: 73,000 af
 Instream flows: up to 100 percent of the NGPRP (1974) recommended instream flows may be provided when inflow to the reservoir exceeds diversion demands

NOTE: In March, May, and June, average subbasin outflows associated with the low level of development (—) exceed average historic monthly outflows (---) because operation of Tongue Dam was assumed to be different after development than in the past.

Figure 3. Tongue Subbasin Monthly Outflows at the Low Level of Development.

Figure 4 shows that a 320,000 acre-foot active storage reservoir on the Tongue River could more than meet the diversion requirements associated with the intermediate level of development in the Tongue subbasin.



ASSUMPTIONS

Level of development: all of the projected intermediate level of development

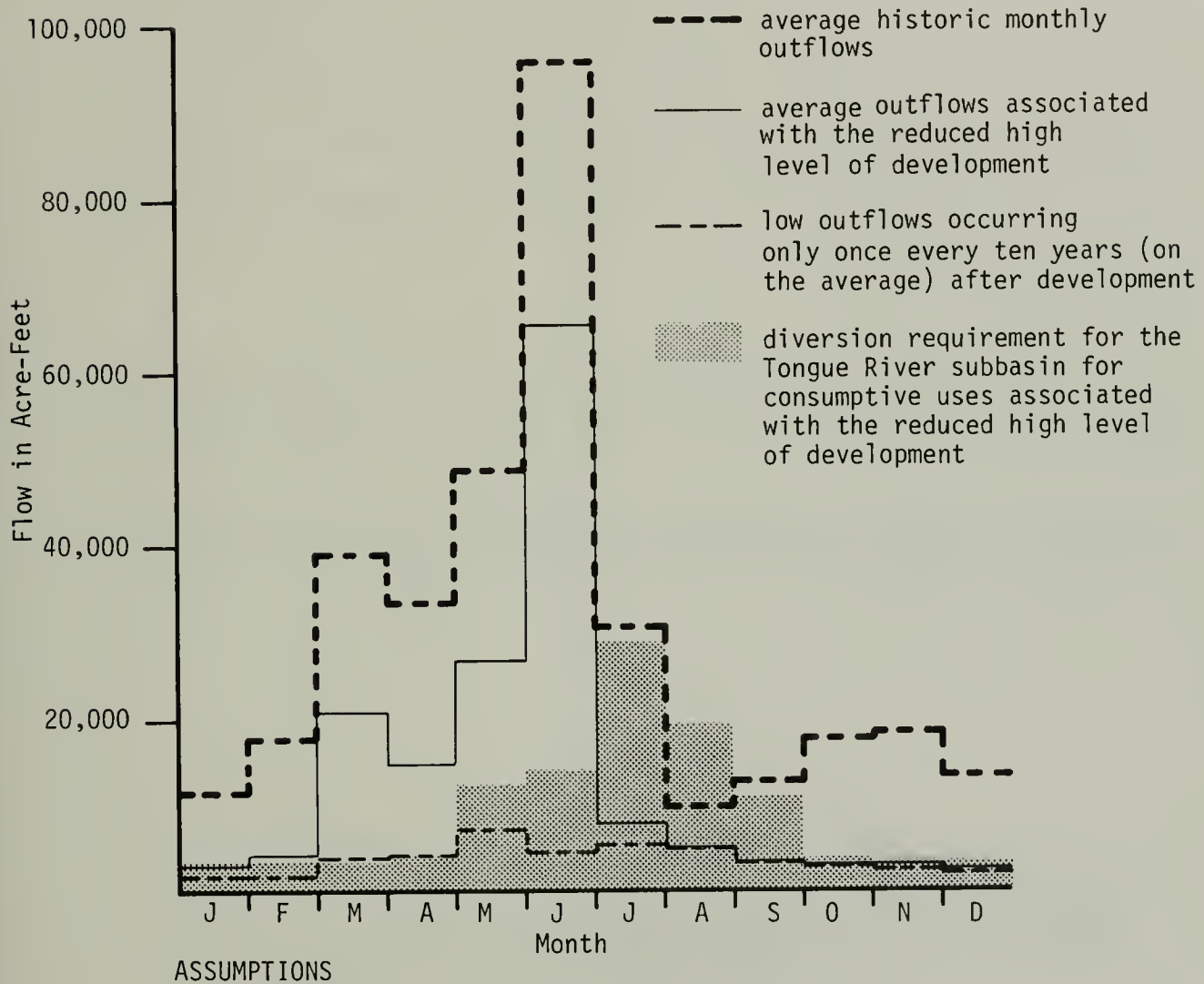
Reservoir active storage: 320,000 af

Subbasin firm annual yield: 134,000 af

Instream flows: up to 60 percent of the NGPRP (1974) recommended instream flows may be provided when inflow to the reservoir exceeds diversion demands

Figure 4. Tongue Subbasin Monthly Outflows at the Intermediate Level of Development.

With regard to the high level of development, figure 5 shows the effect of a 320,000 acre-foot active storage reservoir. Water could be supplied to meet the irrigation demand and provide in-stream flows of 45 cfs during March, April, and May and 15 cfs the rest of the year. Enough water would be left to supply about 28 percent of the energy demand.



Level of development: all of the projected high level of irrigation development and 28 percent of the projected high level of energy development

Reservoir active storage: 320,000 af

Subbasin firm annual yield: 134,000 af

Instream flows: flows of 45 cfs in March, April, and May and 15 cfs all other months

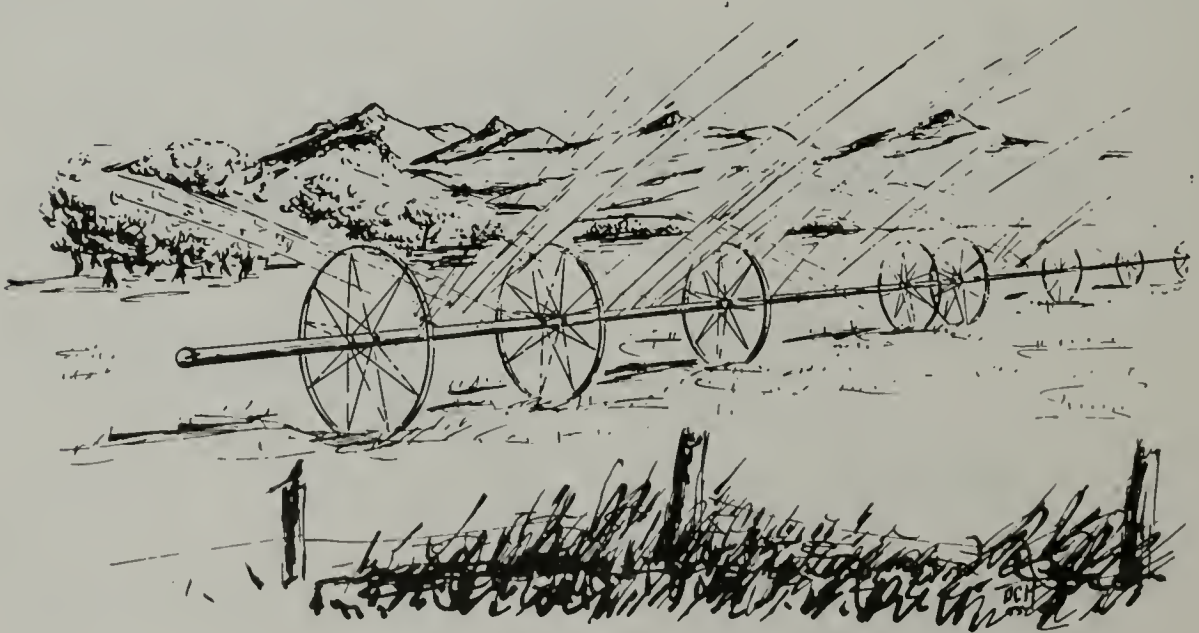
Figure 5. Tongue Subbasin Monthly Outflows at the Reduced High Level of Development.

In a 1969 study, Bechtel Corporation analyzed the availability of water in the Tongue River Basin for allocation under the Yellowstone Compact's terms, one of which provides that Wyoming is entitled to supplemental water for lands partially irrigated prior to 1950. However, according to Bechtel, much of this irrigation will never be developed because of the high cost of delivering water to those lands. A "realistic" allocation was therefore developed based on a reasonable estimate for Wyoming supplemental irrigation water. The study considered a New Tongue River Reservoir, which would be located about 10 miles downstream from the existing dam. Stage I of this reservoir would have an active storage of 320,000 acre-feet and a firm annual yield of 100,000 acre-feet; Stage II would have an active storage of 450,000 acre-feet and a firm annual yield of 112,000 acre-feet. Stage I, considered because the reservoir would lie entirely within Montana, has the same capacity as the reservoir used in the Department's simulations of the intermediate and high levels of development discussed above. The difference in the firm annual yields is due to the difference in assumptions for Wyoming's supplemental irrigation water.

POWDER RIVER

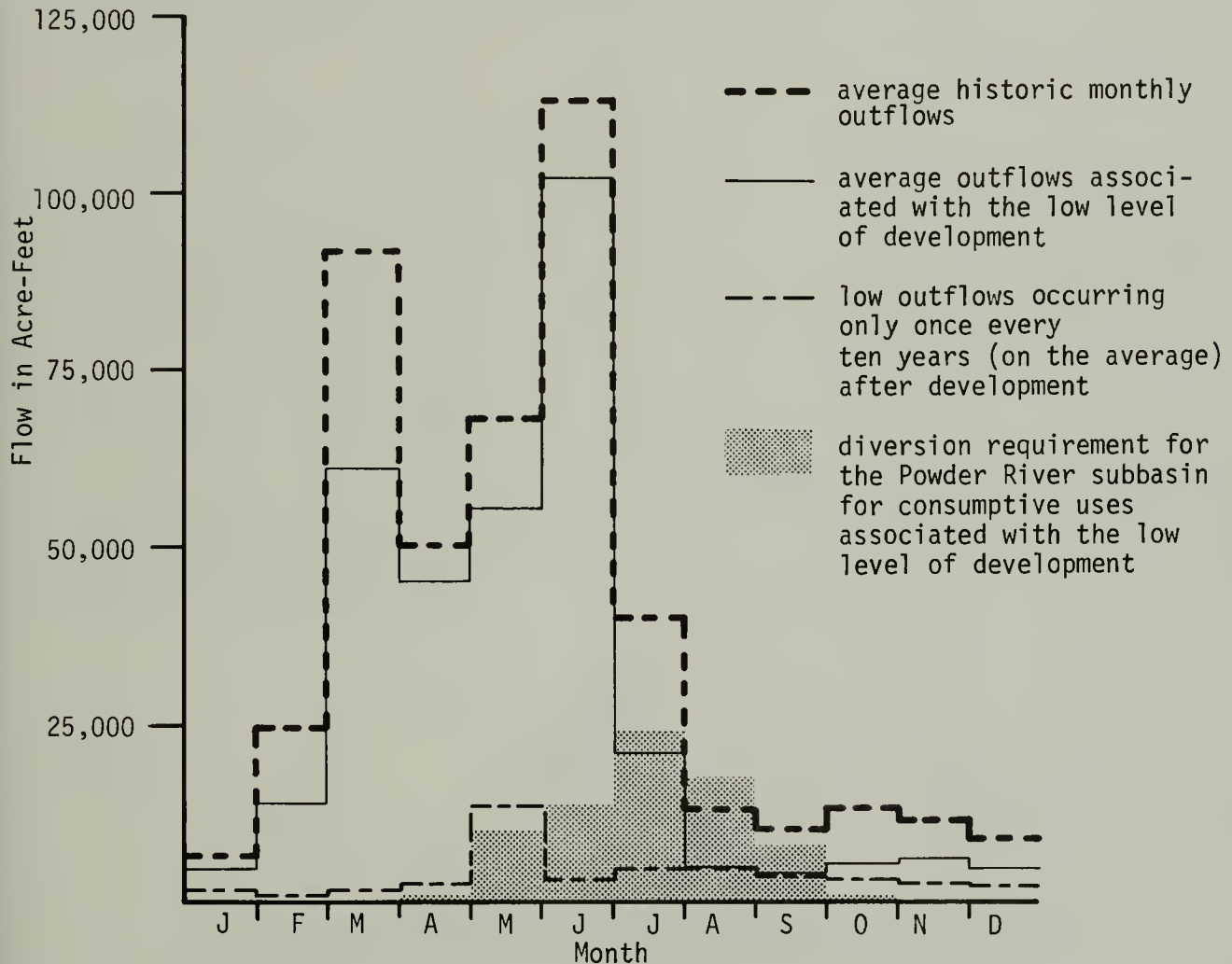
Because there is no storage, water availability problems in the Powder River are acute. At the present level of development, there is no water available for a dependable supply for any substantial energy or agricultural development.

The proposed Moorhead Dam would initially provide an active storage of 835,000 acre-feet. Seventy-seven years after construction, siltation would



have reduced active storage to 275,000 acre-feet, and that figure was used for this analysis. A firm annual yield of 124,000 acre-feet would be provided by an active storage of 275,000 acre-feet. After 77 years, siltation would continue to reduce active storage.

The monthly hydrograph of the Powder River, with Moorhead Dam, is shown in figure 6 for the low level of development. The water supply would be adequate, but instream flows often would be minimal.



ASSUMPTIONS:

Level of Development: all of the projected low level of development

Reservoir active storage: 275,000 af

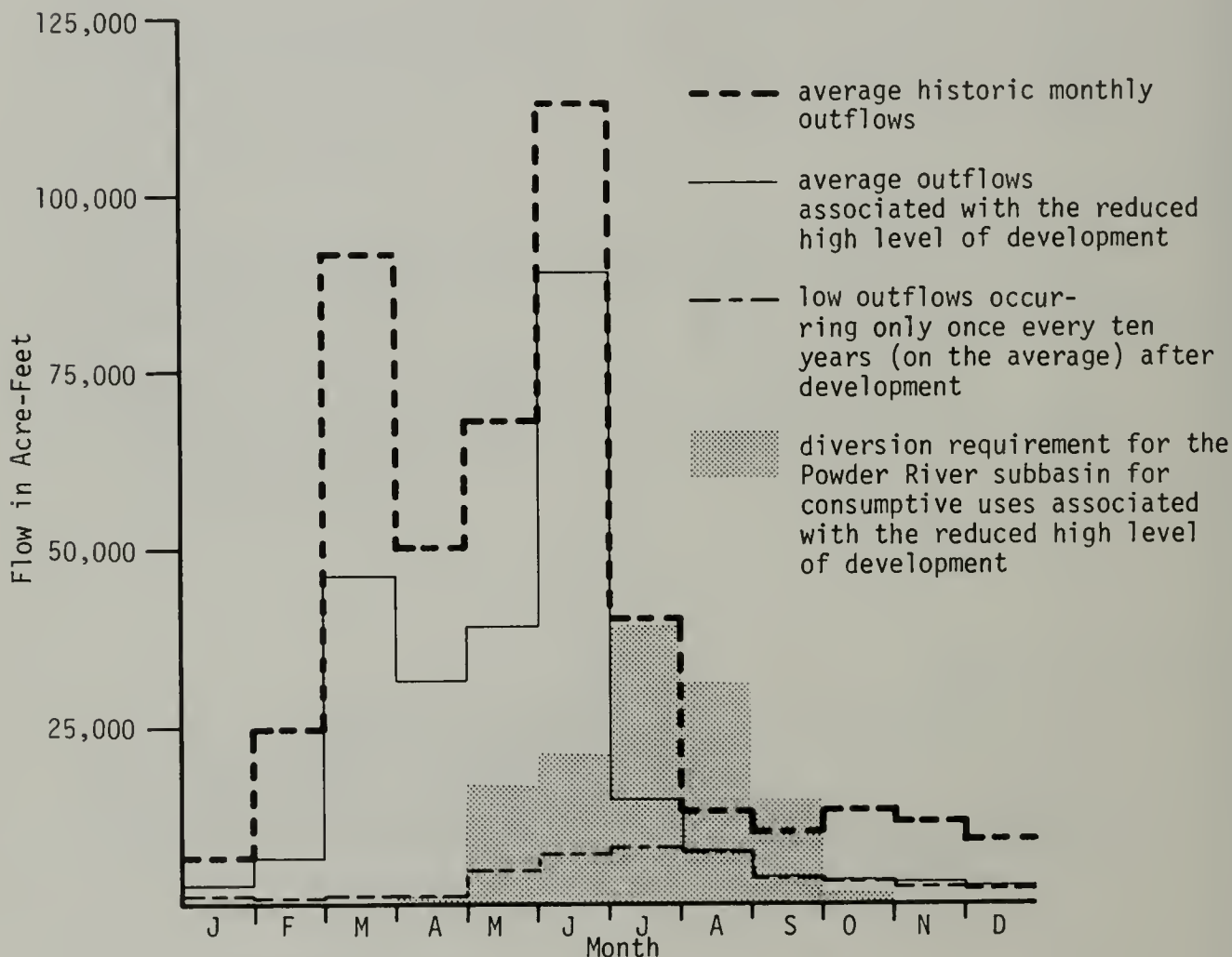
Subbasin firm annual yield: 124,000 af

Instream flows: no provisions are made for instream flows

Figure 6. Powder Subbasin Monthly Outflows at the Low Level of Development.

Even with Moorhead Dam, the demands of the intermediate and high levels of development cannot be met in the Powder subbasin. Figure 7, for example, shows the monthly hydrograph for supplying 55 percent of the high irrigation development but no water for energy. Again, instream flows would sometimes be minimal.

Two additional problems may constrain the level of development in the Powder River Basin. One is the degradation of water quality, discussed in Part III. The second is the likelihood that Moorhead Dam will be too expensive to justify its construction for irrigation development alone. It is therefore necessary to analyze combinations of purposes to determine the combination of water for energy and irrigation that maximizes economic return.



ASSUMPTIONS:

Level of development: 55 percent of the projected high level of irrigation development and none of the projected energy development

Reservoir active storage: 275,000 af

Subbasin firm annual yield: 124,000 af

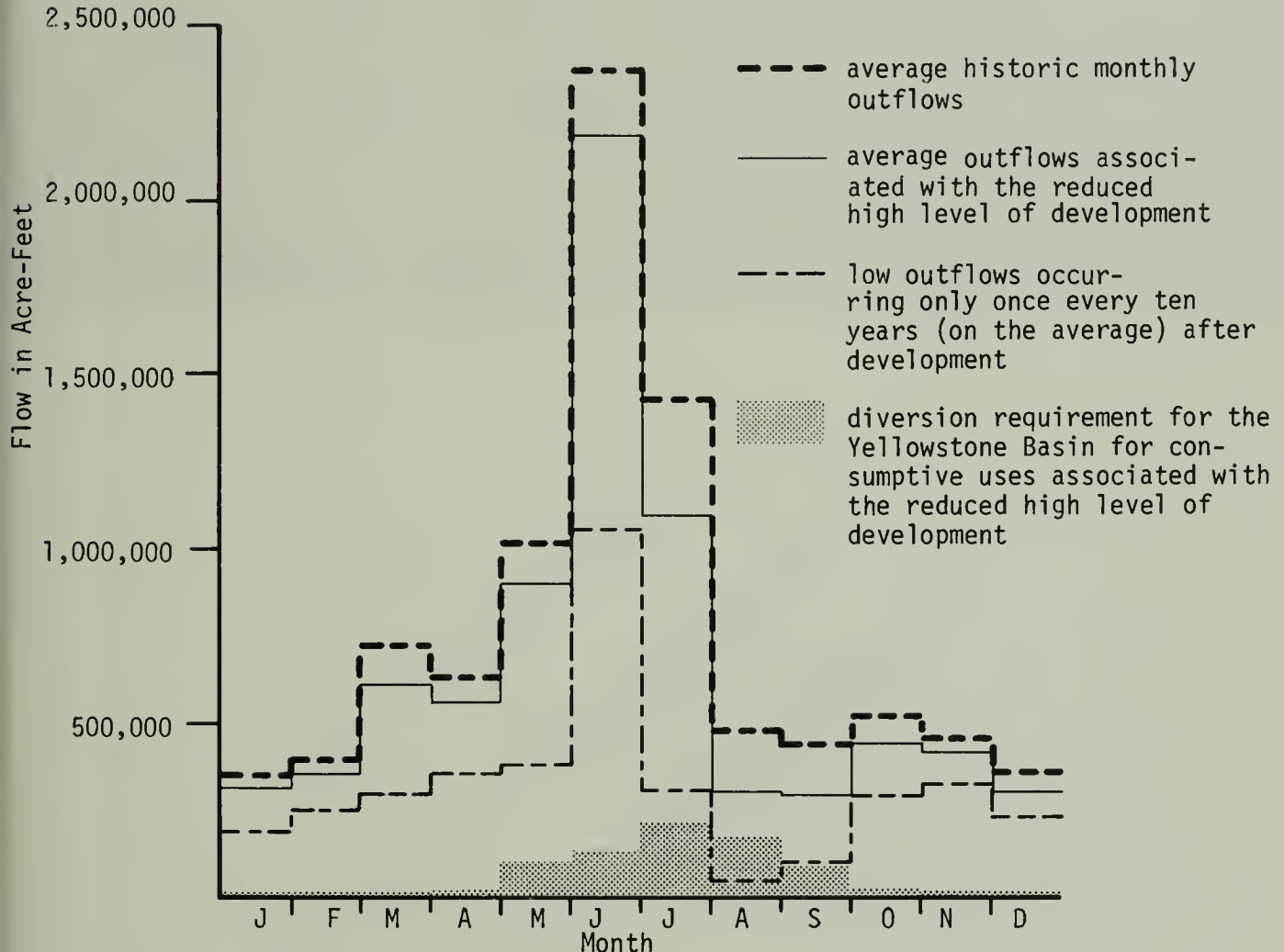
Instream flows: no provisions are made for instream flows

Figure 7. Powder Subbasin Monthly Outflows at the Reduced High Level of Development.

LOWER YELLOWSTONE

The Yellowstone mainstem is free flowing; the only dams on the river are diversion dams. Even though there is no storage on the mainstem, the water supply is adequate throughout most of the river for most months in most years.

Figure 8 illustrates a possible exception. For the high level of development there would always be a sufficient supply of water for diversion and consumption even without mainstem storage, but instream flows would be minimal about one year in ten.



ASSUMPTIONS:

Level of development: all of the projected high level of development, except that, for the Tongue and Powder river subbasins, the high level is reduced as described in figures 5 and 7.

Instream flows: no provisions are made for instream flows.

Figure 8. Lower Yellowstone Subbasin Monthly Outflows at the Reduced High Level of Development.



*The Impact of
Increased Development
on Instream Water Uses*

PART III

The Yellowstone River, its tributaries, and associated riparian land, vegetation, and wildlife make up a complex, interacting, ecological system. This system is influenced by many variables, some of which are relatively unaffected by man, for example, geology and climate. Other variables can and have been manipulated by man, for example, land use (especially agriculture), water pollution, channel form (through such activities as riprapping), and flow (through such projects as dams and diversions).

Flow is of present interest because of pressures to allocate the waters of the basin to various agricultural and industrial developments and because of widespread concern for the maintenance of instream flows. This section of the report summarizes the limited knowledge about the impact of water diversion and consumption on instream uses of water. Basically, this part of the report presents only the general impacts of reduced flows, with no attempt to determine what level of depletion would be necessary to cause them. Where possible, however, the impacts which could result from the levels of development discussed earlier in this report are presented and identified. The information presented here was produced largely through the Yellowstone Impact Study funded by the Old West Regional Commission.

Two of the most important aspects of the river system are water quality and channel morphology (a stream channel's physical characteristics, such as cross-sectional shape, pattern as seen from an airplane, and longitudinal profile). Both are sensitive to man's activities in the watershed, and both influence other important features of the river system, such as riparian wildlife, migratory waterfowl, fish and other aquatic organisms, and recreation.

CHANNEL MORPHOLOGY

CURRENT SITUATION

Yellowstone Basin streams, as they exist today, are the results of dynamic, ongoing channel formation and adjustment processes--erosion, runoff, streamflow, and sediment transport--as well as the geology of the basin. Changes in any of these processes will change the morphology of the channel, which will, in turn, affect other things: the stream bottom habitat available to aquatic insects and other invertebrates, the fish which feed on those invertebrates, the islands used by geese and other migratory waterfowl, and beavers and other furbearing mammals which occupy the land and utilize vegetation adjacent to the river.

Though it has undergone changes, the Yellowstone mainstem exhibits a braided form much like that viewed by Captain William Clark in 1805. This braided form, characterized by multiple channels and islands, is exemplified most by stretches of the river above Forsyth and below Glendive. It provides the necessary habitat for the diversity and abundance of wildlife along the river, but is susceptible to change. Witness the Bighorn River, once also a highly braided river. Since the construction of Buffalo Bill, Boysen, and

Yellowtail dams, the river has consolidated and eliminated islands, tending toward a single channel with fewer backwater areas. Between 1939 and 1974, from Yellowtail Dam to the mouth, the area of the riparian bank increased 38 percent, the total river area (including water, islands, and gravel bars) decreased 25 percent, the vegetated island area decreased 23 percent, and the area of gravel bars decreased 70 percent. A similar, but undocumented, change probably took place on the Tongue River, now essentially a single channel, following the construction of Tongue River Dam.

The impact of several decades of water diversions on the morphology of the Yellowstone mainstem has been small, principally because the mainstem is still essentially free flowing. The natural phenomenon which has the most effect on the form of the river channel is the dominant discharge (that high flow, recurring about every other year, which over long periods transports more sediment than any other flow). This discharge occurs during the June peak; on the average, less than 10 percent of the total June flow is diverted for irrigation. Therefore, neither the dominant discharge nor, consequently, the channel morphology has yet been seriously affected.

The major influence on the channel morphology of the mainstem has been direct modification of the channel by man, including diking, riprapping (which stabilizes the banks and limits the ability of natural processes to operate), and other channel changes.

IMPACTS ON CHANNEL MORPHOLOGY

Future changes in channel morphology resulting from the three levels of development considered in this report may be projected, based on the theories of river dynamics and the history of the river basin.

As a result of the depletions considered here, the form of the Yellowstone mainstem would change, but those changes would be small, subtle, and long term. Small changes in river stage (elevation of the water surface), width, depth, and velocity would occur. For the high level of development, the sediment transport capacity may decrease up to 30 percent. Whether this loss of capacity would cause siltation of the stream bed would depend on the sediment available for transport. The Bighorn River, once a major sediment producer, no longer contributes as much as it once did because of the sediment trap behind Yellowtail Dam. Also, the high development level calls for the construction of Moorhead Dam, which would decrease the contribution of the sediment-laden Powder River.

With regard to the tributaries, development at the levels projected would cause no changes in the Bighorn and Tongue rivers in addition to those resulting from their existing impoundments. A dam on the Powder River would result in severe degradation (down-cutting) of the channel as the stream attempts to regain the sediment load deposited behind the dam. Because the flow reductions in the Clarks Fork Yellowstone River as a result of the projected development are expected to be minor, changes in channel morphology are likewise expected to be minor. There are, however, proposals for dams on the Clarks Fork Yellowstone in Wyoming, which, if constructed, would cause major changes in channel morphology similar to those which occurred in the Bighorn River (described under Current Situation, above).

Without additional impoundment of the rivers, the major factor influencing changes in channel morphology will probably continue to be direct modification of the channel by man. As the number of diversion structures for irrigation or other purposes increases, so will the incidence of channel modification. As agricultural land along the river increases in value because of irrigation, the expected result would be an increase in streambank stabilization (riprapping) to prevent loss of that land.

WATER QUALITY

CURRENT SITUATION

For most uses, water must meet an acceptable standard of quality. For example, irrigation water cannot have excessive concentrations of salts (total dissolved solids) or boron. For municipal use, water should be low in iron, total dissolved solids, bacteria, and temperature, but high in dissolved oxygen. For maintenance of healthy instream habitats for aquatic organisms, water should be high in dissolved oxygen, low in total dissolved solids, and contain adequate, but not excessive, nutrients such as phosphorus and nitrogen.

The water quality analysis reported here centers on total dissolved solids (TDS). Essential to this analysis is the assumption that municipal and industrial water pollution will be effectively prevented by the state through its nondegradation policy, and that the principal effect on water quality would therefore result from dewatering and irrigation returns.

The recommended upper limit for TDS for drinking water is 500 mg/l. For irrigation, TDS concentrations from 500 to 2500 mg/l characterize a water as "high salinity"; it can only be used on well-drained soils and then only with salt-tolerant crops such as sugar beets, wheat, and barley (alfalfa and corn are less tolerant to salts). In addition, excess water must be applied to leach the salts from the root zone. Waters with TDS concentrations in excess of 2500 mg/l are unsuitable for irrigation under most conditions. Using high-salinity water for irrigation may aggravate saline seep problems.

Aquatic ecosystems are also sensitive to high salt concentrations. TDS levels in excess of about 1350 mg/l can be considered detrimental to freshwater systems because of metabolic difficulties for eggs and fry and avoidance by migrating individuals.

For use of water by some industrial processes, TDS is an important consideration. Where TDS concentrations are high, industries may be forced to reduce them through expensive treatment processes.

The existing water quality situation in the Yellowstone Basin is described on pages 17 to 20.

IMPACT ON WATER QUALITY

In the Yellowstone mainstem near Billings, TDS concentrations have historically averaged less than 200 mg/l, exceeding that value only occasionally. Under the high level of development, TDS values, on the average, would not increase significantly, but would show occasional slight increases.

In the mid-Yellowstone mainstem, at the high level of development, TDS concentrations would sometimes exceed 1000 mg/l during August, up from the 600 mg/l or so occasionally experienced during previous Augusts. Average TDS concentrations would not increase significantly during most months; during August, however, the average TDS value would increase from less than 500 mg/l to more than 700 mg/l.

In the lower Yellowstone mainstem, the impact of the high level of development would also be significant. Average TDS concentrations would increase during August from less than 500 mg/l to about 700 mg/l. Occasional August values would exceed 1200 mg/l, up from about 550 mg/l.

In the Bighorn River, TDS concentrations now average less than 600 mg/l. Under the high level of development, the increases would be slight.

Tongue River TDS concentrations average less than 500 mg/l year-round, reaching about 700 mg/l in December and January. During several months, occasional values of 800 mg/l have been noted. Under the high level of development, average TDS values would usually exceed 1000 mg/l and would some years exceed 1600 mg/l year-round.

Water quality impacts in the Powder River would be even greater. Naturally saline with an annual average TDS concentration of over 1100 mg/l, the Powder could show an average of over 1300 mg/l under the high level of development. Occasional September TDS values would increase from about 1800 mg/l to over 3500 mg/l.

It may be reasonably concluded that water quality constraints may determine the level of development finally realized, especially in the Powder River, but also in the Tongue River and to some extent in the other tributaries and the mainstem as well.

FISH AND WILDLIFE

PRESENT RESOURCE

The Yellowstone River has survived as one of the last large free-flowing rivers in America. The lack of mainstem impoundments leaves the spring peak flows and fall and winter low flows to establish a unique ecosystem, adapted to seasonal and yearly flow variations, that supports an abundant variety of wildlife. From the clear, cold-water trout fishery in the headwaters and upper reaches to the turbid warm-water fishery in the lower basin, the river

and its tributaries display a variety of aquatic communities that have remained relatively undisturbed when compared to those of the impounded Missouri, Platte, or Colorado rivers.

The cold-water salmonid fishery is characterized by the presence of cutthroat, rainbow, and brown trout and mountain whitefish. Between Big Timber and Bighorn the river undergoes a transition to the plains warm-water fishery characterized by the presence of carp, goldeye, burbot, stonecat, sauger, walleye, channel catfish, paddlefish, shovelnose sturgeon, and others.

While the Yellowstone River Basin supports a tremendous variety of wildlife including big game species, upland game birds, waterfowl, furbearing mammals, nongame species, raptors, and even endangered species, the river system itself is directly and critically linked to only a portion of these. Canada geese, bald eagles, great blue herons, white pelicans, and several species of ducks use the river for a variety of purposes, including resting, nesting, and feeding. Of the furbearers, only beaver are totally dependent on the stream systems.

IMPACT ON FISH AND WILDLIFE

Fish and riparian wildlife are affected by many interacting variables, among them, flow. Unfortunately, quantification of most relationships between flow and fish and wildlife populations is not possible at this time. It is clear, however, that the many physical and biological components of the river systems are interrelated. For example, significant flow reductions would reduce the population of Cladophora, the dominant algae which provides food and cover for macroinvertebrates and fish.

Impact on the Fishery

Fish are dependent on flow for several life functions: migration, spawning, rearing, and over-wintering. Reduced flows would slightly decrease the amount of stream bottom available as habitat for the many bottom-dwelling invertebrates, essential as food for many fish species. Reduced water velocities over riffles would tend to reduce the populations of mayflies and caddis flies favored as food by goldeye, channel catfish, freshwater drum, young sauger, young burbot, and, especially, shovelnose sturgeon. Loss of side channels and backwater areas would affect fish feeders such as sauger and burbot.

In the Yellowstone mainstem, peak spring flows are necessary to trigger and maintain paddlefish spawning. The dependence of other fish species on flow is less well known.

In the Yellowstone mainstem downstream from Billings, especially in the Lower Yellowstone Subbasin, occasional low flows during August and September at the high level of development would adversely affect the fishery. Insect production in riffle areas would drop markedly. TDS concentrations and temperatures would increase and dissolved oxygen levels would fluctuate widely.

The result would be a decrease in the ability of game fish to survive. Fish populations would shift to a dominance by those nongame fish such as carp which can better cope with adverse environmental conditions.

Dewatering in the vicinity of Billings would cause an upstream shift in the location of the transition zone between the cold-water and warm-water fisheries.

In the Tongue River, the low development level would not have a major impact on the now productive fishery, but the intermediate development level would result in a highly adverse impact. Spawning habitat would be greatly reduced every year; riffles would freeze during most winters; fall flows would approach zero about one out of three years; high flows would be inadequate for paddlefish migration; elevated water temperatures and total dissolved solids would often be a problem. Flow reductions associated with the high projection would dewater the stream to the point that the fishery would be virtually eliminated unless instream flows were guaranteed.

Impacts on the Tongue River Reservoir fishery, however, would be minor; enlargement of the reservoir could expand the fishery.

Impacts on Waterfowl

Effects on migratory waterfowl would result from: 1) changes in channel morphology, water levels, and flows, and 2) changes in land use (more irrigated agriculture).

Stabilization of bars and islands and the subsequent encroachment of vegetation would reduce the populations of nesting Canada geese and loafing waterfowl. Loss of island separation from river banks, or the reduction in width or depth of channels, would increase the accessibility of nesting Canada geese, ducks, and mergansers to predators. It is unlikely, however, as discussed above, that such channel changes will be significant on the mainstem.

In some areas along the Yellowstone mainstem (for example, the Bighorn to Hysham section), geese frequently nest in willow stands which have been thinned by beavers. Any changes which reduce beaver populations would therefore tend to discourage goose nesting.

Open bars and islands are important as loafing areas for migratory waterfowl, as territorial defense sites for breeding ducks and geese, and as secure fishing sites for herons. Loss of these areas by siltation and vegetation invasion would adversely affect these birds.

Many migrant ducks and geese use grain fields for feeding. Any level of development which increases the area of these fields would tend to make the valley more attractive to these migrants. Increases in goose and duck populations would benefit eagles and other predators.

Impact on Furbearers

As with migratory waterfowl, the analysis of the effect of water development on riparian furbearers is subjective. A few generalities hold true, however.

Winter flow reductions can result in freezing of beaver caches and muskrat feed beds; entrances to lodges and bank dens may become exposed or frozen. The results would be increased predation and starvation. Increased winter flows could likewise be detrimental; caches could be washed away.

Low flows in early fall stimulate dam-building activities among beavers. Cutting of willows and young cottonwoods for that purpose would decrease the available food supply, weaken bank resistance to erosion during high runoff periods, and reduce the habitat for other wildlife species such as deer, game birds, songbirds, and raptors. It may enhance goose nesting, however, as pointed out above.

Impoundment-induced channel changes such as those witnessed in the Big-horn River would tend to replace willow stands, the primary food source for beavers, with mature stands of cottonwood. Beaver populations would be accordingly reduced.

RECREATION

PRESENT ACTIVITY

For many, the Yellowstone is primarily a recreational river providing a broad variety of recreational opportunities. The high-country, cold-water trout fishery of Yellowstone National Park and the upper river is of national significance. On the lower river, agate picking is a recreational activity that attracts not only hundreds of Montanans but many out-of-staters as well. In warm weather, boaters make use of the entire river. In the fall, most recreationists are hunters. The warm-water fishery of the middle and lower basin is gaining in popularity. The most important feature of recreation in the middle and lower portions of the basin is that recreation activity at the present time is far less than its potential. That potential has a high but as yet unquantified value.

The Fish and Game Commission has established 230 miles of the Yellowstone River (from Gardiner to Pompey's Pillar) as an outstanding stream under its recreational waterway system (see the "Stream-Fishery Classification" map following page 57). The recreational significance of that river section is evidenced by its addition to Section 5(d) of the Wild and Scenic Rivers Act of 1968 (Public Law 90-542) by the Secretary of the Interior and the Secretary of Agriculture. Section 5(d) of the act states that the two Secretaries "shall make specific studies and investigations to determine which additional wild, scenic, and recreational river areas within the United States shall be evaluated in planning reports by all Federal agencies as potential alternative uses of the water and related land resources involved." The Bureau of Outdoor

CLASS	SIGNIFICANCE	RIVER & REACH	MILES
 1	NATIONAL	YELLOWSTONE RIVER, Yellowstone Park boundary to mouth of Boulder River	103
 2	STATEWIDE	BOULDER RIVER, natural bridge to mouth	34
		YELLOWSTONE RIVER, mouth of Boulder River to rapids	50
		STILLWATER RIVER, below U.S. Forest Service Woodbine Camp	45
 3	REGIONAL	YELLOWSTONE RIVER, rapids to Laurel	20
		BIGHORN RIVER, 20 miles below afterbay	20
		LODGE GRASS CREEK	46
		LITTLE BIGHORN RIVER, above Lodge Grass	51
		EAST ROSEBUD CREEK	36
		WEST ROSEBUD CREEK	30
		WEST FORK STILLWATER RIVER	12
		STILLWATER RIVER, above U.S. Forest Service Woodbine Camp	20
		SLOUGH CREEK	10
		BOULDER RIVER, Upsidedown Creek to natural bridge	24
		WEST FORK BOULDER RIVER, above McLeod	20
		SHIELDS RIVER, below Cottonwood Creek	22
		SWEETGRASS CREEK, above Melville	20
 4	LOCAL		

YELLOWSTONE DRAIN MONTANA

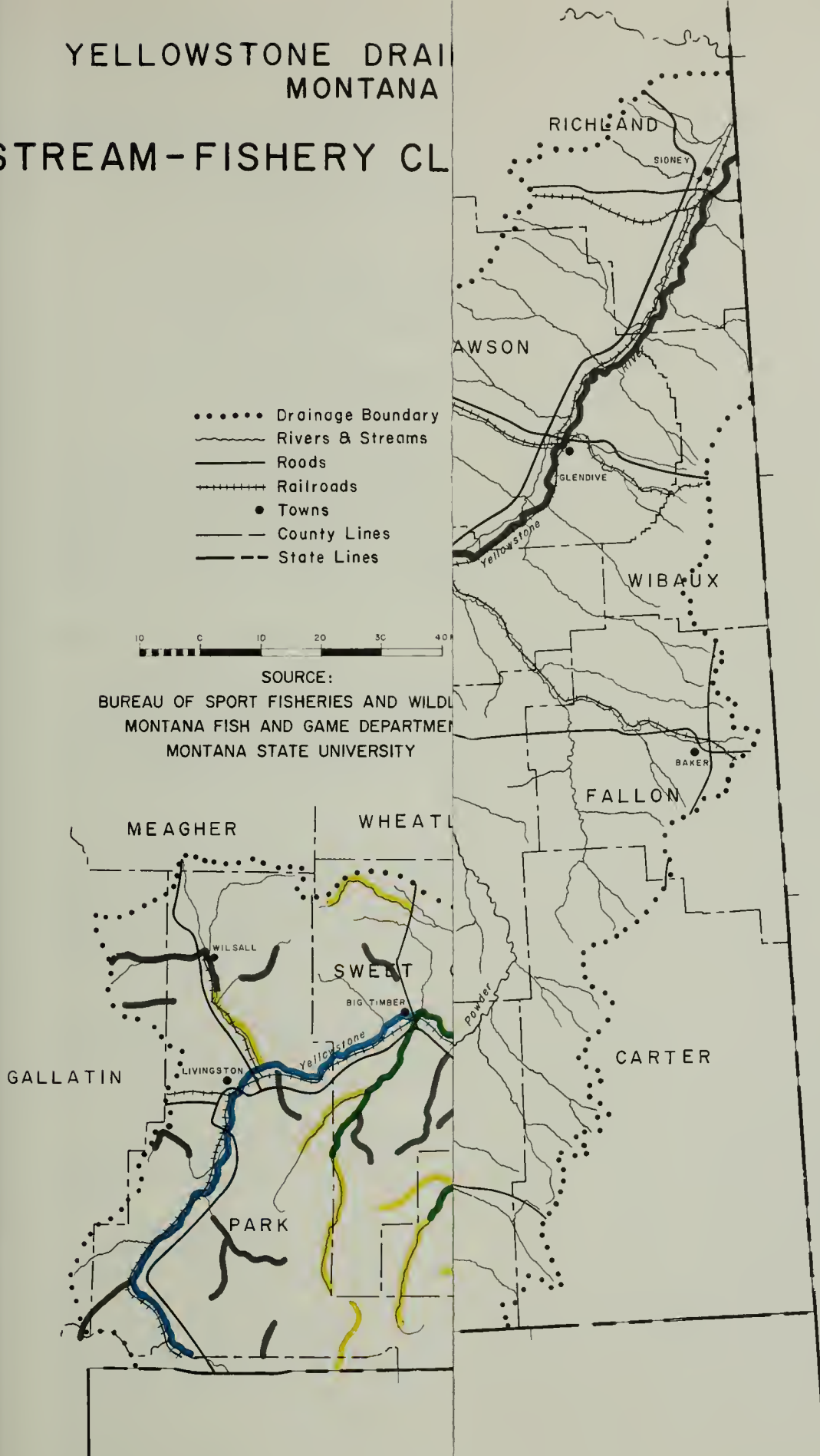
STREAM-FISHERY CL

- Drainage Boundary
- ~~~~~ Rivers & Streams
- Roads
- +++++ Railroads
- Towns
- County Lines
- State Lines



SOURCE:

BUREAU OF SPORT FISHERIES AND WILDLIFE
MONTANA FISH AND GAME DEPARTMENT
MONTANA STATE UNIVERSITY



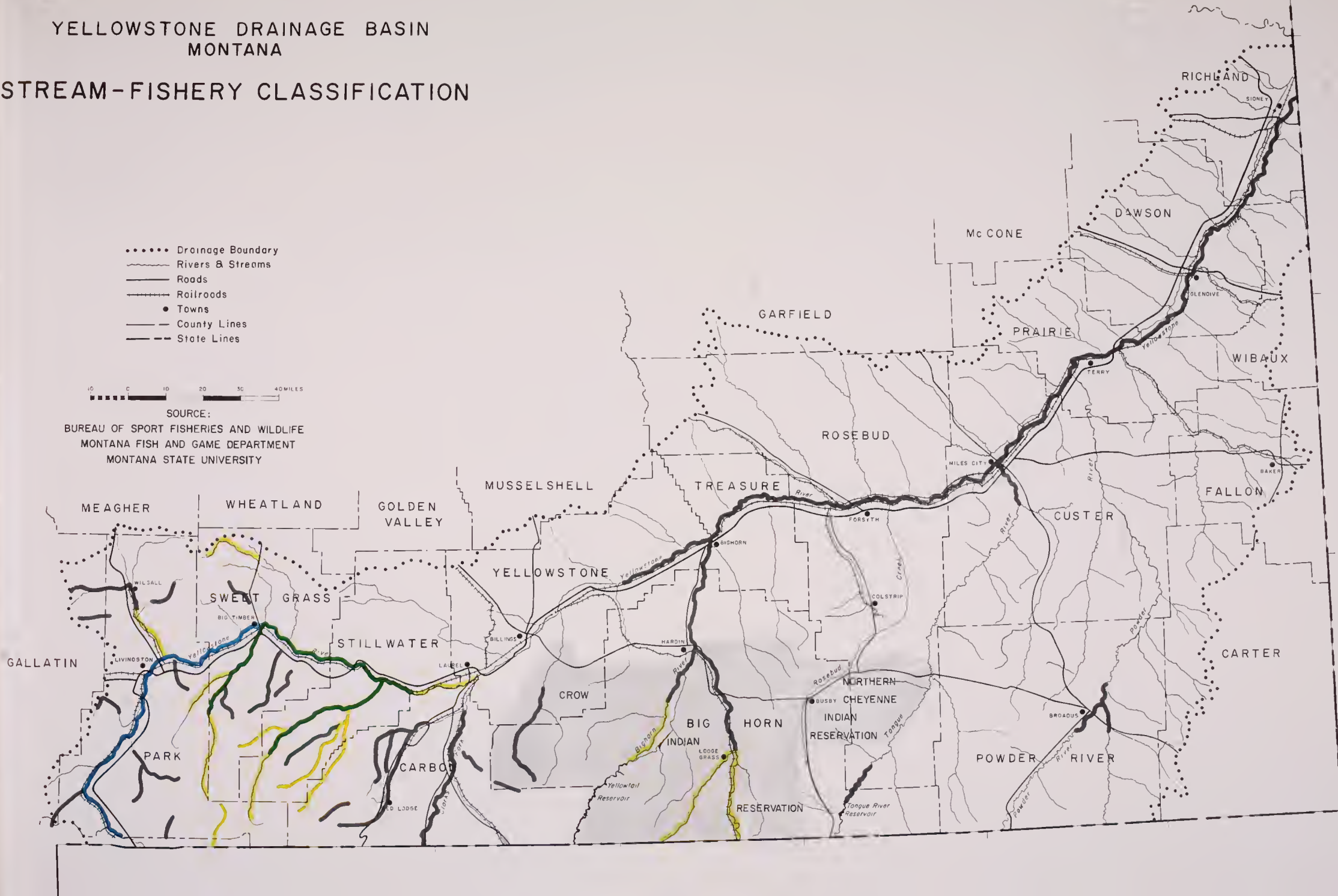
YELLOWSTONE DRAINAGE BASIN MONTANA

STREAM-FISHERY CLASSIFICATION

- Drainage Boundary
- ~~~~~ Rivers & Streams
- Roads
- +—— Railroads
- Towns
- County Lines
- State Lines

0 10 20 30 40 MILES

SOURCE:
BUREAU OF SPORT FISHERIES AND WILDLIFE
MONTANA FISH AND GAME DEPARTMENT
MONTANA STATE UNIVERSITY



Recreation prepared a report (USDI 1975b) which concluded that the Yellowstone meets the criteria for the following classifications:

- 1) The reach from Gardiner to Sportsman's Park (168 miles) meets the criteria for scenic river classification.
- 2) The reach from Sportsman's Park to Spraklin Island (37 miles) does not meet the criteria for classification at the present time but has recreational river potential pending certain land-use rehabilitation measures.
- 3) The reach from Spraklin Island to Pompeys Pillar (20 miles) meets the criteria for scenic river classification.

The study also concluded that the incremental effects of increasing water diversions from the Yellowstone and population growth could jeopardize the river's eligibility for inclusion in the system, and that population growth without land use planning and controls, especially as manifested by vacation home development near the river, poses a serious threat to the values that make the river eligible for inclusion in the system.

IMPACT ON RECREATION

Both recreation activity and recreation potential could potentially be affected by increased development. Population increases would place demands on the system to provide more recreation, yet the system's ability to meet that demand may be reduced by the physical and biological changes associated with water depletions.

Neither the low nor the intermediate level of development would measurably affect recreational activities. Access to the river, now limited by spring and early summer flooding of unimproved roads, would be improved slightly under both the intermediate and high development levels. Certain recreational activities, particularly boating, floating, and waterskiing, would be adversely affected under the high level of development.

Unknown are how each projected level of development would affect fishing success and, if fishing success were decreased, how that decrease would affect the intensity of fishing. Also unknown is how each level of development would affect the supply of agates for rockhounds.

With regard to basin-wide recreation, both fishing and hunting pressures could be expected to increase with increased populations. Attendance at popular camping and other recreation sites could become concentrated.

Some land could become unavailable for recreational use through the siting of development facilities and through an elsewhere-observed tendency of land-owners to close private lands as population and recreational use increase.

The expected reduction in the quality of the Tongue and Powder rivers' waters may affect fishing, hunting, swimming, picnicking, and other recreational use.

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The recreational experience of hikers could be diminished in some areas, since such development facilities as transmission lines intrude upon the natural aesthetic quality. Sightseers who value naturalness and solitude could be similarly affected; those who find the opportunity to tour development facilities interesting and educational would probably be benefited.



Water Rights

PART IV

The actual amount of water available in the Yellowstone Basin for industrial or agricultural development or the provision of instream flows cannot now be positively quantified. Questions in the following five areas must first be resolved: existing water rights, Indian water rights, federal water rights, existing water rights litigation, and the Yellowstone River Compact.

EXISTING WATER RIGHTS

The Montana Water Use Act of 1973 provides a permit system for the appropriation and new use of surface and ground water, procedures for the determination and court adjudication of water rights existing prior to July 1, 1973, and the establishment of a centralized record system of all water rights.

Because of Montana's lack of documentation concerning valid water use, water supply problems, and implications of industrial applications, the DNRC decided that the initial determination of existing water rights would be in the Yellowstone River Basin. Field investigations of water right declarations, part of the process of preparing a recommendation to the district court which issues the preliminary and final decree for adjudication, have been underway since the summer of 1974 in the Powder River Basin; the current status of the process is shown in figure 9. Upon completion of the field investigation, each landowner is interviewed by a DNRC representative to present the findings of the investigation, determine their validity, and collect additional information.

The DNRC estimates that there will be a total of about 11,000 water rights recommended to the district court in the Powder River Basin. Of the 3,000 rights investigated so far, about 75 percent are use rights--rights which have never been filed. Prior to July 1, 1973, use was the only necessary requirement to establish a water right, except on an adjudicated stream; there was no necessity to file. Under the new law, of course, a permit must be obtained for the use of water or there is no right to that water.

The adjudication of the other three interstate tributaries (Tongue, Bighorn, and Clarks Fork Yellowstone) will be completed next. In fact, preparations for the determination of existing rights have begun in the Tongue and Bighorn river basins, but orders for declarations are currently pending because of litigation in federal court over Indian and federal water rights. Adjudication of the mainstem of the Yellowstone River will follow.

Until the adjudication process is completed, quantification of water rights is not possible. Water rights usually are not adequately reflected in historical flow records.

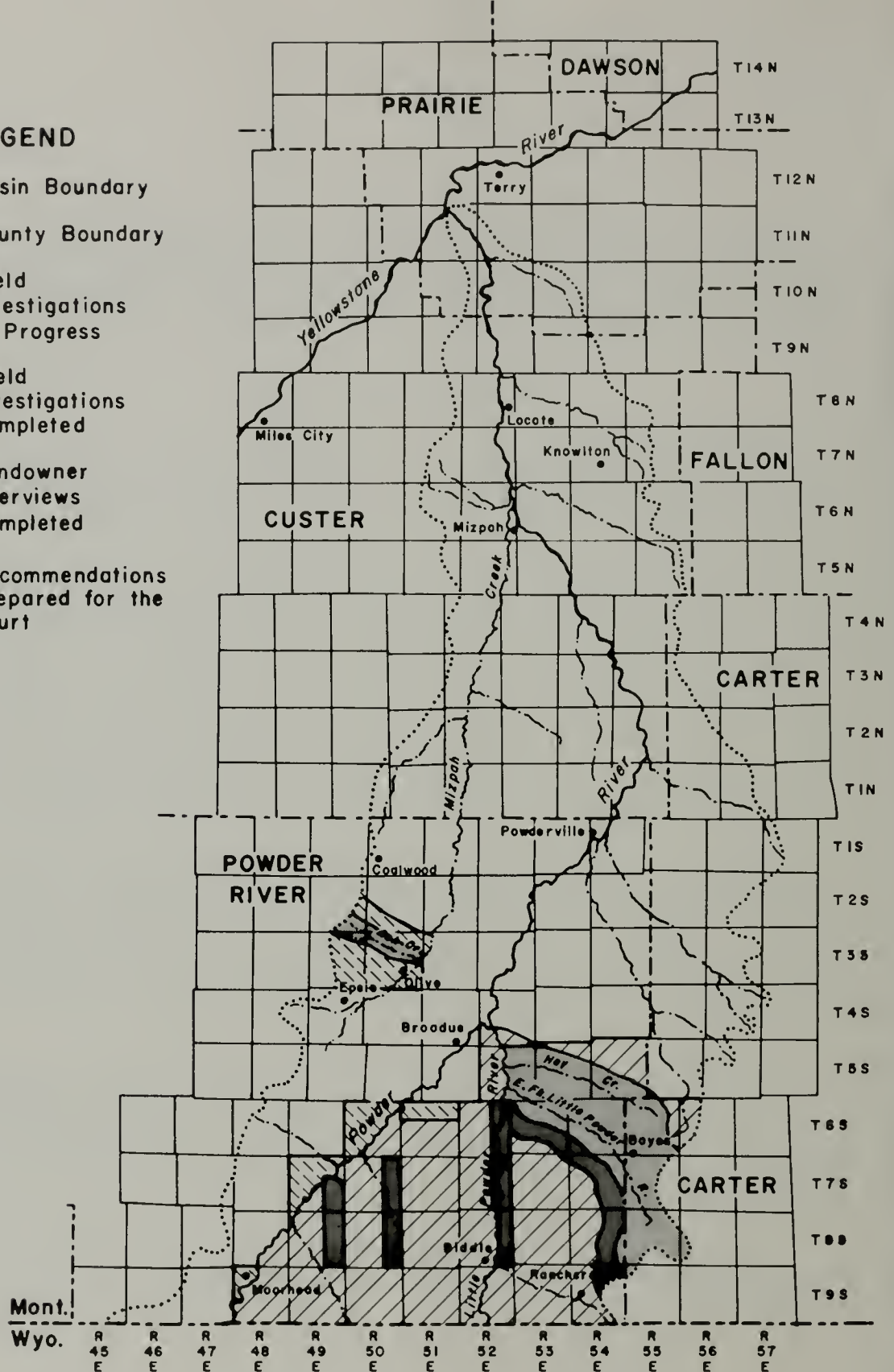
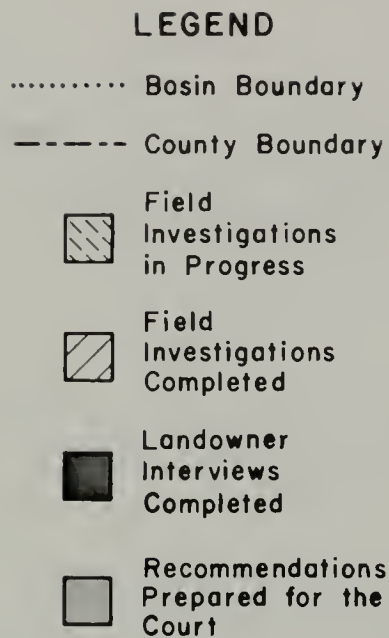


Figure 9. The Status of the Water Rights Adjudication Process in the Powder River Basin, December 1, 1976

INDIAN WATER RIGHTS

Present recognition of Indian "reserved" water rights began with the United States Supreme Court's decision in the Winters case in 1908. The Winters Doctrine, as it has been developed over the years, holds that when the Indian tribes ceded their lands to the United States, reserving smaller tracts for their own use, sufficient water to fulfill their needs on the reservation was also reserved. The measure of the reserved right is in dispute, although some courts have measured the right according to the irrigable acreage on the reservation. The reserved right does not depend upon actual use, and is therefore available for future as well as present needs. Thus, even if the quantity of the reserved right is determined, the question arises as to whether that water can be put to uses (such as coal-based industrialization) which were not contemplated when the reservation was created.

Since major tributaries of the Yellowstone flow by or through both the Crow and Northern Cheyenne reservations, the Indians' reserved rights will affect other water uses. It is possible that Indian reserved rights can be quantified in Montana state courts with the United States acting as trustee of the tribes. If so, much of the uncertainty which currently surrounds Indian reserved rights would be removed.

An estimate by the U.S. Department of the Interior of water requirements on the Yellowstone Basin Indian reservations by the year 2020 is shown in table 15. This federal estimate, obviously much higher than the water use projected earlier in this report for all users even though this is for Indian water use only, is included here primarily to show the potential for conflict.

FEDERAL WATER RIGHTS

Reserved rights attach, not only to Indian lands, but to any lands the United States has withdrawn from the public domain for federal purposes. Upon withdrawing the lands, the United States impliedly withdrew or reserved sufficient water to satisfy the federal purposes. Included in this category are most National Forest lands, national parks, recreation areas, and wildlife refuges. The same problems of quantification seen with Indian rights apply to these federal reserved rights. It is clear, however, that federal reserved rights can be quantified in state courts.

EXISTING WATER RIGHTS LITIGATION

FEDERAL AND INDIAN WATER RIGHTS LAWSUITS

The most important pending litigation concerning water rights in the Yellowstone River Basin concerns three lawsuits currently pending in Federal District Court in Billings. Two of the actions were brought by the United States in its own behalf and on behalf of the Crow and Northern Cheyenne tribes to have adjudicated the water rights in the Tongue and Bighorn river drainages. The third suit was brought by the Northern Cheyenne Tribe in its own behalf to have adjudicated its reserved water rights in the Tongue River and Rosebud Creek. There are several thousand private water users and several state agencies named as defendants in the three lawsuits.

TABLE 15

ESTIMATED INDIAN WATER REQUIREMENTS BY THE YEAR 2020
(ACRE-FEET PER YEAR)

	Crow Reservation	Northern Cheyenne Reservation
Agriculture	1,080,000* (540,000)	109,200 (54,600)
Wildlife	828,300 (0)	178,800 (0)
Energy	196,500 (196,500)	196,500 (196,500)
Industrial	7,000 (1,540)	300 (60)
Domestic	1,800 (400)	1,400 (300)
Recreation	500 (110)	300 (60)
TOTALS	2,114,100 (738,550)	486,500 (251,520)

SOURCE: U.S. Department of the Interior 1975a.

* First number represents water diverted or used instream; the figure in parentheses indicates the amount of water consumed.

These actions have not yet gone to trial, and it is unlikely that they will be tried in the near future. There are currently motions to dismiss before the court, filed by the state and most of the private users. These motions argue generally that the proper forum for adjudication of all of these water rights, federal, Indian, and private, is in Montana district courts pursuant to the Montana Water Use Act. Until this basic jurisdictional question is finally resolved, there will be no further action in these cases.

These actions are important because, whether they are tried in state or federal court, they could answer the question of the extent of federal and Indian reserved water rights in the Yellowstone River Basin. The adjudicating court will have to determine the reserved water rights. It may also determine such important questions as whether the reserved waters can be used or sold for use outside the boundaries of the reservations and whether the Indian right is

ultimately quantifiable, or, as the Indians have claimed, open-ended. In view of the complexity of the pending procedural issues, however, these questions will not soon be answered.

INTAKE WATER COMPANY LAWSUITS

Another important series of lawsuits concerning water rights in the Yellowstone River Basin involves Intake Water Company, Inc., a wholly-owned subsidiary of Tenneco, Inc., of Houston, Texas. The basis of the three separate actions to which Intake is a party is its claim to an existing right to appropriate 111.4 cfs from the Yellowstone River near Intake, Montana. In the first action, Intake has successfully defended its claim against the state of Montana in district court to a perfected appropriation for sale, rental, and distribution for irrigation, industrial, municipal, and domestic purposes. General plans have been revealed to sell water to "companies with energy generating or conversion plants within or outside the State of Montana," including its parent corporation, Tenneco, Inc. The judgment of the District Court upholding Intake's claimed appropriation is currently under appeal by the state in the Montana Supreme Court.

A separate action instituted by Intake against the Yellowstone River Compact Commission in Federal District Court seeks a declaratory ruling that Article X of the Yellowstone River Compact is unconstitutional in that it requires unanimous consent of the three signatory states before any water can be diverted from the Yellowstone River Basin. This case is currently stayed, pending a resolution of the issues in the lawsuit mentioned in the preceding paragraph, and none of the issues raised has yet been resolved.

In a third separate action, Intake has sued the DNRC in Montana District Court seeking a declaratory ruling that its planned diversion of 111.4 cfs from the Yellowstone River, for the purposes described above, is not subject to the Montana Major Facility Siting Act (Section 70-801 et seq., R.C.M. 1947). This case is also currently pending.

The outcome of all three of these actions is important because there are several corporations with similar large claims for Yellowstone Basin water for industrial purposes. Furthermore, the action in Federal District Court is the first to interpret and challenge the Yellowstone River Compact. Thus, final resolution of these actions could determine the validity of other claimed rights from the Yellowstone and could significantly affect the future administration of the Yellowstone River Compact.

Another series of lawsuits to which Intake Water Company is a party involves competing water development projects on the Powder River between Intake and Utah International, Inc. The issues raised are complex, but generally involve the question of whether Intake or Utah International has the prior claim to water from the Powder River. The two lawsuits--one in State District Court and the other in Federal District Court--require interpretation of the Yellowstone River Compact and the water appropriation laws of the states of Montana and Wyoming. Both actions are currently pending, awaiting resolution of preliminary jurisdictional and procedural issues.

YELLOWSTONE RIVER COMPACT

The Yellowstone River Compact, executed by Montana, Wyoming, and North Dakota, and ratified by the United States Congress in 1950, was designed to allocate water of the Clarks Fork Yellowstone, Bighorn, Tongue, and Powder rivers. The compact recognizes water rights prior to 1950, those rights designated to provide supplemental water supplies to land irrigated prior to 1950, and water rights for irrigation projects started before 1950. The compact divides the remaining water according to percentages of the flow at the mouths of the streams as shown in table 16.

TABLE 16

DIVISION OF WATERS UNDER THE YELLOWSTONE RIVER COMPACT

Tributary	Wyoming	Montana
Clarks Fork Yellowstone	60%	40%
Bighorn	80%	20%
Tongue	40%	60%
Powder	42%	58%

Article X of the compact prohibits diversion of water out of the Yellowstone Basin without the unanimous consent of the signatory states. This article has recently become controversial because Wyoming would like to divert water out of the basin for use by the energy industry. Montana's position at this time is to withhold approval of such diversions until the two states can agree on quantification of the percentages of tributary flows. Wyoming has published its estimates of these quantities, as presented in table 17. Montana does not necessarily agree and intends to independently calculate its compact share.

TABLE 17

WYOMING'S YELLOWSTONE COMPACT ESTIMATES (ACRE-FEET)

	Wyoming	Montana
Clarks Fork Yellowstone	429,000	285,000
Bighorn	1,800,000	400,000
Tongue	96,400	144,700
Powder	120,700	166,600
TOTAL	2,446,100	996,300

SOURCE: Wyoming State Engineer's Office 1973



*Resolving the Conflicts -
The State Water Plan*

PART V

POTENTIAL SOLUTIONS TO SOME WATER CONFLICTS IN THE YELLOWSTONE BASIN

The conflicting demands for Yellowstone water, both present and potential, have been presented in the preceding parts of this report. Reconciliation of these conflicts requires thorough consideration of each potential solution described below.

WATER RESERVATIONS

A major provision of the Water Use Act is that Montana or any of its political subdivisions or agencies, or the United States or any of its agencies (with the exception that no federal agencies may apply in the Yellowstone River Basin until the end of the Yellowstone Moratorium, explained below), may apply to the Board of Natural Resources and Conservation to reserve water. These reservations may be made for existing or future beneficial uses or to maintain a minimum flow, level, or quality of water. A reservation has the same legal standing as a permit. Those water rights with earlier priority dates must be honored first until their needs for beneficial uses are met.

The Yellowstone Moratorium, enacted in 1974, affected major applications for appropriations of greater than 20 cubic feet per second (cfs) or a planned storage of greater than 14,000 acre-feet in the Yellowstone River Basin. The DNRC may not take any action on these applications until March 11, 1977. The moratorium also provides that water reservation requests adopted by the Board before these major applications for permits are acted upon will have a preferred use over those applications. Major applications for permits for beneficial use thus affected are shown in appendix B.

The thirty reservation applications for the Yellowstone Basin received to date are also listed in appendix B. The largest has come from the Montana Fish and Game Commission, which requested a reservation of 8.2 mmcf/y for instream flow in the Yellowstone mainstem at Sidney. Additional requests were submitted concerning major and minor tributaries. Fifteen conservation and irrigation districts, eight municipalities, and three other state agencies also filed applications for reservations.

The Board has not yet acted on Yellowstone reservation applications and will not until the DNRC completes an environmental impact statement on those applications in February, 1977, and holds public hearings; a review, comment, and objection period for affected water right holders, reservation applicants, state and federal agencies, and the general public must also be provided before the Board takes action.

IRRIGATION WATER MANAGEMENT

By reducing irrigation water waste, more water could be made available for further diversion or instream use.

Main canals are sometimes kept full throughout the irrigation season, even though actual water need may be small. In these cases, more water is diverted than is needed, with much water being lost from the irrigation system at wasteways, which increases the total loss, even though much of this water returns to the stream. Water users who divert from main canals argue that, if main canals are drained, water will not be available for irrigation on demand. Some of the larger canals, if drained, could take an inconveniently long time to fill so that users could divert from them again.

Water costs are generally low compared to farm labor costs, sometimes resulting in wasteful water application practices. Over-application of irrigation water not only wastes water but also leaches fertilizer, resulting in financial losses and degraded water quality downstream. (However, excess water application may be needed in some cases to leach salts which have accumulated in the root zone).

Sound management techniques can correct these problems and result in less water being diverted to irrigate the same number of acres.

Contributing to irrigation problems is the deterioration with age of the water distribution networks in the basin. These systems also aggravate water losses, but can be upgraded by such means as canal and ditch lining, proper wasteway construction, and provisions for adequate cross drainage structures.

In many areas water users have legal rights to water lost by irrigators above them, and their rights could be adversely affected by the use of more efficient irrigation practices. Even though irrigation management may provide more water for other uses, thorough and comprehensive studies must be completed so that all water rights can be protected.

INCREASED STORAGE

The primary purpose of a reservoir is to retain water in periods of high flow for use during times of drought or shortage. Total reservoir capacity refers to the maximum amount of water the reservoir can hold; however, some of this storage cannot be used for downstream diversion requirements because the reservoir must be maintained at minimum levels for recreation and hydropower purposes and because reservoir storage must be provided for flood flows when they occur. The storage available for storing water for consumptive use, therefore, is normally less than the total capacity.

Firm yield is the most important aspect to consider when matching water availability with demand, since it is the maximum quantity of water that can be guaranteed annually from the reservoir even during dry years. Firm yield is affected by physical factors, such as reservoir characteristics and monthly and yearly fluctuations of streamflow, and institutional factors, such as existing water rights, interstate compacts, and instream flow provisions.

New reservoirs could alleviate some of the basin's water supply problems, but not all. The Allenspur dam site alone could furnish 1.5 mmcf of water annually and still provide a measure of fishery protection through releases for instream flows. However, the reservoir would inundate 35 miles of "Blue Ribbon" trout stream and 32,000 acres of agricultural land, much of which is irrigated hay land. Lissa, another mainstem reservoir site, would provide more water and perhaps be less degrading environmentally. A series of three offstream sites, Sunday Creek, Cedar Ridge, and Buffalo Creek, could provide a major portion of the water that would be firmed up by Allenspur and, according to a Fish and Game Department evaluation (Montana Department of Fish and Game 1975), be less damaging to the fish resource. Storage must be built before any significant new water development can take place in the Tongue and Powder river basins.

Table 18 shows the storage potential of selected reservoirs; a more complete listing of sites is given in the "Potential Reservoir Sites and Major Industrial Water Applications" map following page 29.

TABLE 18

STORAGE AND COST COMPARISON OF SELECTED POTENTIAL
YELLOWSTONE BASIN RESERVOIRS

SELECTED RESERVOIR SITE	TOTAL CAPACITY (af)	FIRM YIELD (af/y)	SURFACE ACRES	COST (1976 Dollars)	WATER CHARGE (\$/af/y+)
Allenspur	4,000,000	1,483,000*	31,900	380,282,000	
Lissa	2,180,000	1,944,000*	40,000	170,248,000	
Sunday Creek**	678,000	957,000*	13,700	167,040,000	
Cedar Ridge	127,000	70,000*	4,700	35,788,000	31
Buffalo Creek	73,000	40,000*	1,900	54,104,000	81
New Tongue Stage I	320,000	100,000***	7,600	63,194,000	39
Stage II	450,000	112,000***	9,000		
Moorhead	1,150,000	129,000*	18,500	93,776,000	41

*NGPRP 1974. Figures are based on the following assumptions:

1. All water requirements are for industrial use.
2. Fish and Wildlife Service recommended instream flows are maintained except for Moorhead, where, for the Powder River, only 10% of the recommended flows are honored.

**The firm yield of the Sunday Creek offstream storage site is larger than the total capacity of the reservoir because the firm yield includes the amount of water available from the mainstem Yellowstone.

***Bechtel 1969

+No water charge figures are available for the Allenspur, Lissa, or Sunday Creek sites because no information is available regarding the quantity of water that would be marketed from those reservoirs. Interest during construction was computed using 6% interest and a probable construction period. Investment was amortized for 50 years at 5 3/4%. Costs for Stage II of the New Tongue site have never been estimated.

The firm yields shown in table 18 for the Allenspur, Lissa, Sunday Creek, Cedar Ridge, and Buffalo Creek sites were taken from the NGPRP's Report of the Work Group on Water (1974) and indicate water available after allowing for a fairly high level of instream flows (4.3 mmf/y at Sidney). The firm yield of Moorhead shown also comes from that report but assumes only a low level of instream flows. Firm yields shown for the New Tongue site are results of a 1969 Bechtel study prepared for the DNRC and include effects of the Yellowstone Compact but do not allow for instream flows.

ALTERNATIVE ENERGY TRANSPORTATION SYSTEMS AND CONVERSION TECHNOLOGY

Transporting Coal

The principal current means of transporting coal is by railroad unit cars.

Slurry pipelines are a method by which a coal and water mixture can be shipped from the mine to the area of conversion. The Yellowstone Impact Study projections show no slurry export from the state at the low level of development, but slurry is included in the intermediate and high levels. It should be noted that under present law the use of water for slurry to export coal from Montana is not a beneficial use.

A 1,000-megawatt electric generation plant requires about 4 million tons of coal per year; conversion of that coal would require about 15,000 acre-feet of water each year. Since 750 acre-feet of water is needed to move one million tons by coal slurry pipelines, exporting the same amount of coal by slurry would require only 3,000 acre-feet of water annually. Only negligible amounts of water would be consumed in exporting the same amount of coal by rail.

Obtaining Water

Many coal beds are miles away from surface water sources adequate to supply coal conversion facilities. Thus, for coal conversion, coal must be shipped to the water source, surface water must be delivered to the coal sites, or ground water must be developed.

Aqueducts. One means of transporting water to Montana's coal fields for use in the conversion process is by aqueduct. The Bureau of Reclamation's Appraisal Report on Montana-Wyoming Aqueducts (USDI 1972a) identified feasible aqueduct routes throughout the Yellowstone Basin. The Northern Great Plains Resource Program has estimated the cost of water delivered through aqueducts to vary from about \$25 to \$370 per acre-foot, depending on the distance the water is conveyed (NGPRP 1974).

Ground Water. Ground-water aquifers near the surface do not generally yield sufficient water for large-scale development except in the alluvium; however, deep aquifers may be able to provide an amount of water sufficient for industrial use. The Madison Group constitutes the top part of these aquifers. Large-yield water wells can be developed in areas of sufficient

Madison Group thickness. The Madison and underlying carbonates contain water of moderate-to-good quality that is probably suitable for industrial use, although marginal-to-unsatisfactory for irrigation. The cost of Madison ground water would vary between \$27 and \$48 per acre-foot (NGPRP 1974).

Depths to water, yields, and water quality vary widely for the Madison Group, and more specific studies must be completed before industries will be willing to drill for that water. The Geological Survey is presently coordinating a study that will more closely define characteristics of the Madison ground water.

Dry Cooling

Water, essential in all energy development facilities, is used primarily for cooling in the coal conversion process. As shown in table 19, wet cooling systems consume large amounts of water, while dry cooling techniques are the most water-conservative of the cooling alternatives.

While dry cooling facilities use less water than other cooling methods, they are also the most expensive. However, recent studies have indicated that, if the cost of water reaches approximately \$200 per acre-foot (Stroup and Townsend 1974), dry cooling techniques become economically feasible. Though far from common, generation plants using dry cooling do exist. The Neal Simpson Station (27 mw) outside of Gillette, Wyoming, was the first coal-fired electrical generation plant in the United States to use dry cooling. The Wyodak plant, now under construction at the same site and scheduled for completion early in 1977, will also use dry cooling; it will generate 330 mw of electricity and consume from .2 to 1 mgd (Black Hills Power and Light Company and Pacific Power and Light Company 1973). In comparison with the 5 mgd consumed by each of Colstrip Units 1 and 2, which each generate 350 mw, the Wyodak plant is obviously more water-conservative.

TABLE 19

WATER REQUIREMENTS FOR COAL-FIRED ELECTRIC GENERATING PLANTS

Cooling System	Depletion (af/y/1,000-mw unit)
Evaporative Cooling	15,000
Pond	10,000
Once Through	3,600
Dry Cooling	2,000

SOURCE: Western States Water Council 1974

ADJUDICATION

Resolving the conflicts over water use in the Yellowstone Basin requires that the present water rights be known. As explained earlier in this report, adjudication of existing rights is proceeding, but slowly. Acceleration of that process would be helpful, but that acceleration would, of course, require more professional staff for DNRC.

STATE WATER PLANNING PROGRAMS

Development of a comprehensive, coordinated, multiple-use water plan for the state was authorized under the Montana Water Resource Act of 1967. That plan, to be known as the State Water Plan, will constitute state water policy; it will set the guidelines for the selection of a course of development of Yellowstone Basin water, and, indirectly, the type of Yellowstone Basin coal development. The water availability discussions in this report show that there is not sufficient water for maximum irrigation development and maximum energy development in all areas of the basin. The State Water Plan may provide a method of determining how much irrigation and how much coal development can or will be accommodated, and to what extent development will be allowed to affect such instream uses as recreation and maintenance of fish and wildlife habitat.

The DNRC's efforts toward fulfilling the mandate of the Water Resource Act have consisted of the publication of a series of reports detailing the state's water resources and participation in a number of studies which have provided and will provide the basis for formulation of the plan. Beyond that, there are temporary but serious obstacles to the finalization of the State Water Plan. One is the unsettled legal status of water rights in the basin. Another is that, although the act calls for coordination of all federal, state, and local activities in the planning and utilization of the state's water resources, it provides no mechanism for implementation of that coordination. Consequently, the water planning program has had to rely on every available resource to achieve some semblance of coordination from the different levels of government. Montana's membership in two river basin commissions, federal-state entities established by the President, has provided a measure of federal and interstate coordination.

One of the studies in which Montana is participating that provides direct input into the State Water Plan is a level B (reconnaissance) study of the Yellowstone Basin and adjacent coal areas, for which federal funding was made available through the Missouri River Basin Commission. Montana had requested this study, hoping for a start in the fall of 1974. The study management was established in July 1975, and the study got underway in January 1976. Because the formulation of the State Water Plan is heavily dependent on the results of this study, that delay resulted in a corresponding change in the projected schedule of the Yellowstone portion of the State Water Plan. Originally scheduled for completion early in 1977, that date has now been delayed until mid-1978 (see figure 10) to allow incorporation of the Yellowstone Level B Study results.

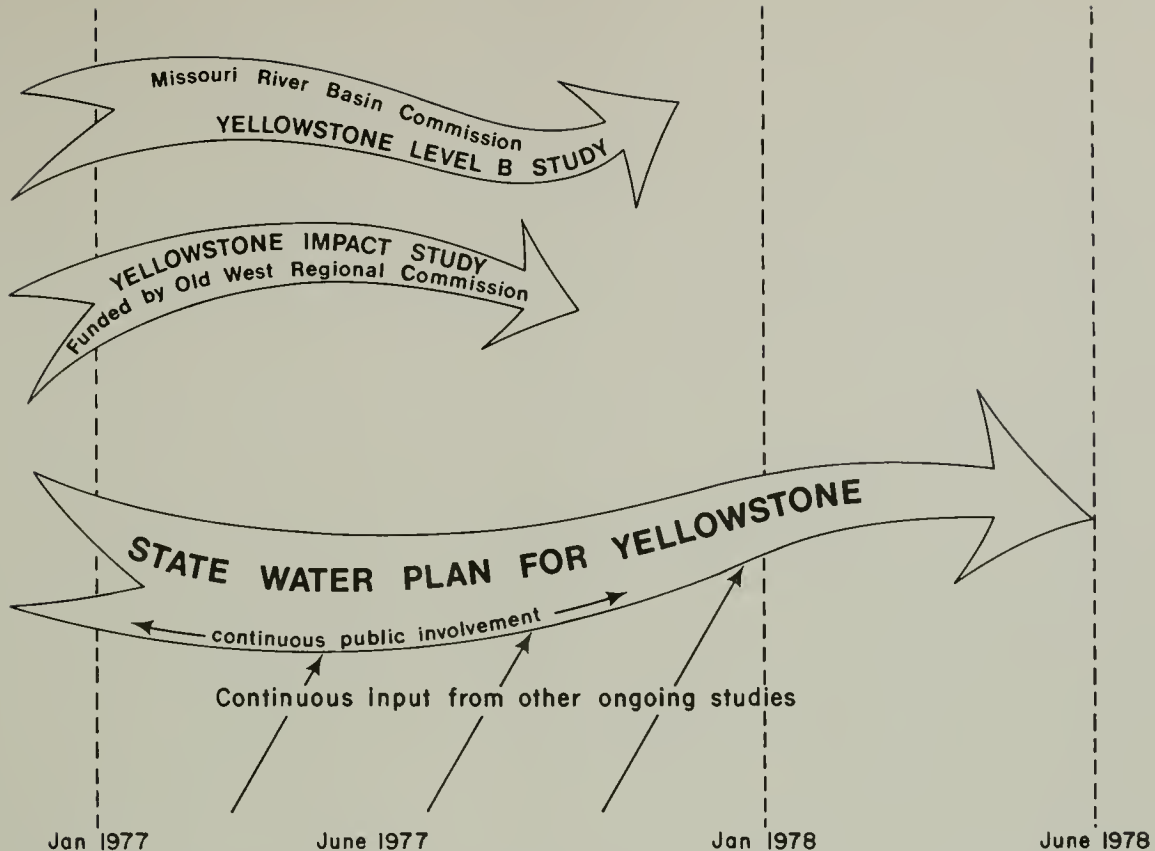


Figure 10. Preliminary Schedule for the Completion of the State Water Plan and Associated Studies

The federal funding for the Yellowstone Level B Study provides only for study management and participation from the concerned federal agencies. In order to provide state input, a state planning team was formed to include representatives from various state agencies, thereby drawing upon available expertise.

One shortcoming of the Level B Study is that it must rely on existing, available data with no provision for collecting new information. Montana is fortunate to have a number of ongoing or recently completed studies that are providing valuable information to the Yellowstone Level B Study. A significant contribution is coming from the Yellowstone Impact Study funded by the Old West Regional Commission. Started in mid-1974, this study is providing an analysis of the physical and biological impacts of water withdrawals on the middle and lower reaches of the Yellowstone River and its major tributaries. With funding provided by the U.S. Bureau of Reclamation, DNRC updated for this study the inventory of irrigated lands in the Yellowstone Basin. Much of the previous data was at least 30 years old, so this effort was essential to determining the present status of irrigated agriculture in the basin.

Special studies on the Tongue and Powder rivers were provided for by the 1975 Legislature as part of the Renewable Resources Development Act (HB 642). These studies, being conducted by the DNRC, are examining alternatives for developing additional storage on the Tongue River and the desirability and feasibility of providing storage on the Powder River, presumably at the Moorhead site.

APPENDIXES

APPENDIX A
CONVERSION TABLES

TABLE A-1
WATER AND COAL REQUIREMENTS FOR COAL PROCESSES

Process	Water	Coal
Thermal-electric generation	15,000 af/y/1,000 mw	4 mmt/1,000 mw
Gasification	9,000 af/y/250 mmcf/d	7.6 mmt/250 mmcf/d
Syncrude	29,000 af/y/100,000 b/d	18 mmt/100,000 b/d
Fertilizer	13,000 af/y/2,300 t/d	3.5 mmt/2,300 t/d
Slurry	750 af/mmt	
Strip Mining	50 af/mmt	

TABLE A-2
WATER UNIT CONVERSIONS

Multiply...	By...	To Obtain...
Flow		
Million gallons per day (mgd)	1.55 1,121 694	cubic feet per second (cfs) acre-feet per year (af/y) gallons per minute (gpm)
Cubic feet per second (cfs)	3.07 724 .646	acre-feet per day acre-feet per year (af/y) million gallons per day (mgd)
Volume		
Acre-feet	326,000 43,560	gallons cubic feet
Cubic feet	7.5	gallons

APPENDIX B

MAJOR REQUESTS FOR THE APPROPRIATION OR RESERVATION OF YELLOWSTONE BASIN WATER

This appendix includes four tables. Table B-1 lists major industrial filings for Yellowstone water for industrial use; these were made before July 1, 1973. Table B-2 lists major applications for Yellowstone Basin water for industrial use received since the enactment of the 1973 Water Use Act, all of which are affected by the moratorium on Yellowstone water. Table B-3 includes all applications received as of the publication of this report for the reservation of Yellowstone water for beneficial use. The final table, B-4, describes filings made by the Montana Fish and Game Commission on the Yellowstone mainstem in 1970. Such filings for instream use were possible in Montana only on some stream sections and only between the passage of the Montana Water Resource Act of 1967 and the passage of the Montana Water Use Act of 1973.

TABLE B-1
MAJOR INDUSTRIAL FILINGS FOR APPROPRIATION OF
YELLOWSTONE BASIN WATER

Date of Filing	Filed by	County of Application	Source	Amount	Purpose
6/8/73	Intake Water Company	Dawson	Yellowstone River	111.4 cfs (50,000 gpm) up to 80,650 af/y	to be sold, rented, and distributed for irrigation, industrial, municipal, and domestic purposes
12/22/70	Montana Power Company	Rosebud	Yellowstone River	250 cfs continuously	industrial use in a thermal-electric generating plant
4/5/73	Sherman and Stuart Hunt	Rosebud	Yellowstone River	200 cfs	irrigation, stockwater, domestic, and industrial purposes
9/6/50	Montana Power Company	Yellowstone	Yellowstone River	200 cfs	industrial use in a thermal-electric generating plant
4/5/66	Montana Power Company	Yellowstone	Yellowstone River	200 cfs	industrial use in a thermal-electric generating plant
6/29/73	Basin Electric Power Cooperative	Rosebud	Yellowstone River	50 cfs	industrial use in a thermal-electric generating plant

TABLE 8-2
MAJOR INDUSTRIAL APPLICATIONS FOR YELLOWSTONE BASIN WATER

Applicant	Source	Appropriation Request	Proposed Uses	Estimated Cost
Utah International, Inc. No. 1004-s42J	Powder River Sec. 31, T. 58 N., R. 75 W. Campbell County, WY	400 cfs up to 106,730 af/y with offstream storage on Fence Creek.	82,705 acre-feet, industrial 2,090 acre-feet, municipal 7,610 acre-feet, irrigation and reclamation 14,325 acre-feet, fish and wildlife	\$38 million
Montana Storage Company No. 1205-s42C	Tongue River Sec. 28, T. 1 S., R. 44 E. Rosebud County, MT	675 cfs up to 130,000 af/y offstream storage on Lay Creek and 55 cfs up to 40,000 af/y direct diversion	Rent, sale or distribution for industrial, domestic, wildlife, municipal, agricultural, and recreational uses	\$10.3 million
Water Reserve Company No. 1271-s42C	Tongue River Sec. 18, T. 6 N., R. 48 E. Custer County, MT	500 cfs up to 91,000 af/y offstream storage on Squaw Creek and Mill Creek and 50 cfs up to 36,200 af/y direct diversion	Rent, sale, or distribution for industrial, agricultural, domestic, municipal, fish and wildlife, and recreational uses	\$12.5 million
Getty Oil Company No. 1391-s42M	Yellowstone River Sec. 35, T. 18 N., R. 56 E. Oawson County, MT	250 cfs up to 32,000 af/y offstream storage on Thirteenmile Creek and 89.2 cfs up to 60,000 af/y direct diversion	Industrial, municipal, irrigation, domestic, recreational, and fish and wildlife uses	\$4 million
Mobil Oil Company No. 5440-s42M	Yellowstone River Sec. 35, T. 19 N., R. 57 E. Richland County, MT	60 cfs direct diversion up to 35,000 af/y (alternative 1) or 400 cfs peak diversion up to 50,000 af/y for offstream storage (alternative 2)	Industrial uses (conversion of coal to synthetic fuels and byproducts)	\$31.1 million
Intake Water Company No. 3763-s42J	Powder River Sec. 19, T. 9 S., R. 48 E. Powder River County, MT	564,400 af/y for mainstem storage	245,000 acre-feet, industrial 35,000 acre-feet, municipal 38,700 acre-feet, irrigation 245,700 acre-feet, sediment storage	\$35.7 million
Gulf Mineral Resources No. 4045-4058	Yellowstone River; Pumpkin, Lignite, Coal, and Mizpah creeks; ground-water wells	210 cfs up to 90,000 af/y, of which, depending on the alternative chosen, portions will be diverted directly or stored offstream Possible storage sites and their respective capacities: Pumpkin Creek, 86,310 af Lignite Creek, 50,410 af Coal Creek, 29,240 af Mizpah Creek, 77,525 af Ground-water wells will produce 10 cfs each and will be 5,000 - 10,000 ft in depth	Industrial, municipal, domestic, irrigation, fish and wildlife, and recreation	\$11.2 million to \$50.9 million

TABLE B-3

APPLICATIONS FOR RESERVATIONS OF WATER IN YELLOWSTONE BASIN

Applicant	Source	Amount	Use
Park Conservation District	Yellowstone & Shields River	752 cfs/108,143 acre feet per year (af/y)	Irrigation (36,570 acres)
Sweet Grass Conservation District	Yellowstone River, Boulder River & various tributaries	438.7 cfs/55,822 af/y	Irrigation (18,510 acres)
Stillwater Conservation District	Yellowstone River & Stillwater River	122.1 cfs/16,755 af/y	Irrigation (5,290 acres)
Carbon Conservation District	Yellowstone River, Clarks Fork, Rock Creek, Red Lodge Creek	274.2 cfs/47,557 af/y	Irrigation (21,015 acres)
Yellowstone Conservation District	Yellowstone River	378.2 cfs/62,900 af/y	Irrigation (26,785 acres)
Big Horn Conservation District	Big Horn River, Tongue River	151 cfs/21,200 af/y	Irrigation (9,645 acres)
Treasure Conservation District	Yellowstone & Big Horn Rivers, Sarpy & Tullock Creeks	129 cfs/19,978 af/y	Irrigation (7,645 acres)
Rosebud Conservation District	Yellowstone, Tongue Rivers, Armell's & Rosebud Creeks	585 cfs/94,129 af/y	Irrigation (37,360 acres)
North Custer Conservation District	Yellowstone River, Tongue River & Powder River	732.4 cfs/104,237 af/y	Irrigation (36,965 acres)
Powder River Conservation District	Powder River, Tongue River, & various tributaries	583.2 cfs/83,060 af/y	Irrigation (30,245 acres)
Prairie County Conservation District	Yellowstone River	512.9 cfs/63,127 af/y	Irrigation (20,646 acres)
Dawson County Conservation District	Yellowstone River	325 cfs/45,149 af/y	Irrigation (17,897 acres)
Richland County Conservation District	Yellowstone River	354.2 cfs/45,620 af/y	Irrigation (21,710 acres)
Huntley Project Irrigation District	Yellowstone River	92 cfs/27,372 af/y	Irrigation (4,000 acres)
Buffalo Rapids Irrigation Project	Yellowstone River	167 cfs/124,434 af/y	Irrigation (41,306 acres)
Department of State Lands	Numerous tributaries in Yellowstone Basin	15,078 af/y	Irrigation (10,270 acres)
Department of State Lands	Numerous tributaries in Yellowstone Basin	143.64 cfs/21,429 af/y	Irrigation (7,143 acres)
Department of State Lands	Numerous tributaries in Yellowstone Basin	218.03 cfs/30,898 af/y	Irrigation (10,376 acres)
City of Livingston	Yellowstone River	20.8 cfs/15,060 acre feet per year (af/y)	Domestic, Municipal
City of Big Timber	Yellowstone River	6.19 cfs/4,483 af/y	Domestic, Municipal
City of Columbus	Yellowstone River	3.6 cfs/2,606 af/y	Domestic, Municipal
City of Laurel	Yellowstone River	23.2 cfs/16,830 af/y	Domestic, Municipal

TABLE B-3 continued

Applicant	Source	Amount	Use
City of Billings	Yellowstone River	1,190 cfs/317,456 af/y	All Beneficial Uses
City of Miles City	Yellowstone River	30 cfs/21,720 af/y	Municipal
Town of Broadus	Ground Water	0.84 cfs/605 af/y	Municipal
City of Glendive	Yellowstone	17.62 cfs/12,756.9 af/y	Domestic, Municipal
Department of Natural Resources and Conservation	Tongue River	450,000 acre-feet (af)	Irrigation, Industrial, Fish & Wildlife
Department of Natural Resources and Conservation	Powder River & tributaries	1,150,000 af	Irrigation, Industrial, Fish & Wildlife
Montana Fish and Game Commission	Yellowstone Basin and numerous tributaries	Variable monthly flows; 8,206,723 af/y for Yellowstone River at Sidney	Water Quality, Fish & Wildlife, Recreation
Department of Health and Environmental Sciences	Yellowstone River	6,643,000 af/y for Yellowstone River at Sidney	Water Quality

TABLE B-4

MONTANA FISH AND GAME COMMISSION FILINGS ON THE DESIGNATED
BLUE-RIBBON REACH OF THE YELLOWSTONE RIVER

Reach	Dates	Amount
Yellowstone Park Boundary to Tom Miner Creek	Jan 1 to Dec 31	800 cfs
Tom Miner Creek to Shields River	Apr 16 to Oct 31	2,000 cfs
	Nov 1 to Apr 15	1,200 cfs
Shields River to Boulder River	Apr 16 to Oct 31	2,000 cfs
	Nov 1 to Apr 15	1,200 cfs
Boulder River to Stillwater River	Apr 16 to Oct 31	2,200 cfs
	Nov 1 to Apr 15	1,300 cfs
Stillwater River to North-South Carbon-Stillwater County Line	Apr 16 to Oct 31	2,600 cfs
	Nov 1 to Apr 15	1,500 cfs

SOURCE: Montana Fish and Game Commission unpublished

APPENDIX C

METHODOLOGY OF THE IRRIGATION FEASIBILITY STUDY

Irrigation costs were separated into water delivery costs and application costs. Annual costs of delivering water to the farm gate were developed for each lift and length category. Basic data were provided by the U.S. Bureau of Reclamation, and a computer program was used to select the most efficient pump and pipe size for each category, based on both initial and annual operation costs.

Water application costs were developed from information provided by the Cooperative Extension Service (1969). The costs of a center-pivot sprinkler system were used, since this type was used on over half of all new irrigation systems installed since 1973 (Montana DNRC 1975b).

Costs for both the water delivery system and the application system include both initial costs and annual operation costs. The initial cost of all pumps, pipe, houses, electrical equipment, and installation was converted to an annual cost using a capital recovery factor (CRF) at 10% interest with a 10-year loan period, terms slightly better than the prevalent rate and loan period at the time the study was begun. This amortized cost was then added to the annual operation costs (labor, maintenance, repairs, and electricity) and divided by the irrigated acres to determine total irrigation costs per acre per year.

Farm budgets were used to compute the per-acre capacity to pay all irrigation costs. Separate farm budgets were prepared for each subbasin to reflect local farming practices. All crops produced in each area were placed into four categories and an average cropping pattern developed to represent the historical patterns. Sugar beets were used to represent all high-value cash crops such as beets or dry beans. Barley represents the grains; alfalfa represents all hay crops; and corn silage represents all silage crops including ensiled hay or beet tops.

The farm budgets compute the costs and profits associated with crop production, plus generalized farm costs such as investment, maintenance, and repair of buildings and fences. Since the budgets include all costs associated with a farm enterprise, including adequate payments to the farmer for his labor, management, and investment, all remaining profit may be used to pay irrigation costs. This profit margin was then compared to the total irrigation costs for each lift and length category. Maximum pumping lifts and distances were identified for each subbasin, and the total acreage feasible to irrigate was determined.

APPENDIX D

MUNICIPAL WATER USE IN THE YELLOWSTONE BASIN

One conclusion of this report was that, of the three main consumptive water uses in the Yellowstone Basin (energy, irrigation, and municipal), municipal water use would be by far the least demanding on the basin's water resources in the future. Depletion for municipal use projected in the three levels of development presented here would range from 5,880 af/y for the low projection in 2000 to 10,620 af/y for the high, compared with from 158,340 af/y to 474,960 af/y for irrigation and from 48,350 af/y to 321,190 af/y for energy water use. This appendix includes data on 1970 municipal water use in the Yellowstone Basin (table D-1), population simulations for the year 2000 (table D-2) used in projecting future municipal use, and the projected increases in depletion for municipal use in 2000, by subbasin (table D-3).

TABLE D-1
MUNICIPAL WATER USE IN THE YELLOWSTONE BASIN
IN 1970

County	Number of Cities having Municipal Systems	Population Served	Water Use in mgd			Per Capita Water use, in gpcd
			Ground Water	Surface Water	Total	
Big Horn	6	5,089	.235	.791	1.026	201
Carbon	6	3,592	.512	.679	1.191	332
Custer	1	9,070	.390	1.558	1.948	215
Dawson	3	8,244	.489	.991	1.480	179
Park	6	8,017	.361	1.766	2.127	265
Powder River	2	1,099	.146	0	.146	132
Prairie	0	0			0	
Richland	2	5,499	1.223	0	1.223	222
Rosebud	5	5,353	.671	.333	1.004	187
Stillwater	3	1,845	.634	0	.634	343
Sweet Grass	1	1,592	.855	0	.855	537
Treasure	1	373	.125	0	.125	335
Yellowstone	5	86,749	.175	16.976	17.151	198
TOTAL	38	136,522	5.816	23.094	28.910	
AVERAGE						212

TABLE D-2
YELLOWSTONE BASIN POPULATION SIMULATIONS FOR 2000

City	Population*	Population Simulations for 2000		
		Low Level of Development	Intermediate Level of Development	High Level of Development
Ashland	531	2,379	3,423	7,236
Billings	63,729	94,999	95,523	98,294
Birney	13	60	70	137
Broadus	799	4,138	6,096	10,692
Busby**	300	1,160	1,038	2,036
Colstrip	200	5,044	5,824	15,107
Forsyth	1,873	5,189	5,664	10,249
Glendive**	6,441	8,341	8,341	8,713
Hardin	2,733	4,783	5,458	7,094
Lame Deer**	650	1,062	1,012	1,442
Lodge Grass	806	1,090	1,215	1,462
Miles City	9,023	15,890	16,461	20,254
Sidney**	4,551	6,032	6,032	6,404

SOURCE: Prepared by the Montana Department of Community Affairs for the Yellowstone Impact Study.

*Populations given are the most recent available census or estimate. In Ashland, Birney, Busby, Colstrip and Lame Deer, the 1970 census population is given; all others are 1975 censuses or estimates.

**In Busby and Lame Deer, the projected population is less in the intermediate level of development than in the low; in Glendive and Sidney, it remains constant. The overall basin population increases from the low to the intermediate level of development, but, because the locations of coal development change, the projected population shifts from one area to another.

TABLE D-3

THE INCREASE IN WATER DEPLETION FOR MUNICIPAL USE IN 2000 BY SUBBASIN

Subbasin	Population Increase	Increase in Depletion (AF)
LOW LEVEL OF DEVELOPMENT		
Upper Yellowstone	0	0
Clarks Fork	0	0
Billings Area	31,270	3,480
Bighorn	2,050	negligible
Mid-Yellowstone	15,030	1,680
Tongue	1,788	negligible
Kinsey Area	0	0
Powder	3,339	360
Lower Yellowstone	3,381	360
Total	56,858	5,880
INTERMEDIATE LEVEL OF DEVELOPMENT		
Upper Yellowstone	0	0
Clarks Fork	0	0
Billings Area	31,804	3,540
Bighorn	2,755	300
Mid-Yellowstone	16,800	1,860
Tongue	2,900	300
Kinsey Area	0	0
Powder	5,300	600
Lower Yellowstone	3,381	360
Total	62,940	6,960
HIGH LEVEL OF DEVELOPMENT		
Upper Yellowstone	0	0
Clarks Fork	0	0
Billings Area	34,565	3,900
Bighorn	4,361	480
Mid-Yellowstone	34,494	3,840
Tongue	6,705	780
Kinsey Area	0	0
Powder	9,900	1,140
Lower Yellowstone	4,125	480
Total	94,150	10,620

APPENDIX E

SUMMARY OF QUESTIONNAIRE RESPONSE

From October 26 to 29, 1976, public meetings were conducted by the Department of Natural Resources and Conservation in six Yellowstone Basin cities (Sidney, Glendive, Miles City, Forsyth, Billings, and Livingston) to present information and receive public comment. A draft version of this report, entitled Which Way? The Future of Yellowstone Water, was distributed at those meetings, along with a related questionnaire entitled "Your Response to Which Way? The Future of Yellowstone Water." Approximately 300 copies of the report and questionnaire were distributed to the general public and to agency representatives at those meetings; 98 questionnaires were filled out and returned. A summary of the response to that questionnaire is presented here. The questionnaire is reproduced on pages 101 to 103.

Each question is listed below in italics; following, in regular type, are (1) the number of valid responses to the question and (2) the response itself, shown as percentage of valid responses. For example, after the first question, the number of valid responses is given as 95, which means that 95 people answered the question with either a "yes" or a "no." The number shown under "yes" is 82 percent meaning that, of the 95 people who responded, 82 percent, or 78 people, answered "yes."

The number of valid responses varies widely from question to question because some respondents did not answer all questions and some answered in ways that did not permit comparison with most other responses--for instance, giving more than one response to the same question. Responses in these categories were not considered valid and were not tabulated.

I

1. *Regarding water rights in the basin:*

- a) *Should the Yellowstone Moratorium on large appropriations of water, which will expire in March of 1977, be extended until the State Water Plan is adopted?*

<u>Number of valid responses</u>	<u>Yes</u>	<u>No</u>
95	82%	18%

- b) *Should more tax money be expended to speed up the process of adjudicating water rights?*

<u>Number of valid responses</u>	<u>Yes</u>	<u>No</u>
91	56%	44%

- c) Should more tax money be expended to assist local governments in applying for water reservations and in refining plans after reservations are granted?

<u>Number of valid responses</u>	<u>Yes</u>	<u>No</u>
84	54%	46%

- d) Should the state of Montana establish a legal defense fund to be used for the protection of existing and future water rights?

<u>Number of valid responses</u>	<u>Yes</u>	<u>No</u>
87	77%	23%

2. Before additional water is appropriated for consumptive use, should some level of instream flow be guaranteed to maintain fish and wildlife habitat, water quality, and recreation?

<u>Number of valid responses</u>	<u>Yes</u>	<u>No</u>
89	80%	20%

3. Identify the projected level of development (as presented in the report) that you would find acceptable:

- a) in your subbasin?

This question presented two major columns, ENERGY and IRRIGATION, with three choices under each--high, intermediate, and low.

ENERGY

<u>Number of valid responses</u>	<u>High</u>	<u>Intermediate</u>	<u>Low</u>
76	10%	45%	45%

IRRIGATION

<u>Number of valid responses</u>	<u>High</u>	<u>Intermediate</u>	<u>Low</u>
79	58%	37%	5%

- b) in the entire Yellowstone Basin?

ENERGY

<u>Number of valid responses</u>	<u>High</u>	<u>Intermediate</u>	<u>Low</u>
78	12%	51%	37%

IRRIGATION

<u>Number of valid responses</u>	<u>High</u>	<u>Intermediate</u>	<u>Low</u>
82	54%	41%	5%

4. *In the future, should some uses of water be preferred over others?*

<u>Number of valid responses</u>	<u>Yes</u>	<u>No</u>
70	100%	0%

If so, how, on a numerical scale using 1 to indicate first preference, 2 to indicate second preference, and so on, would you rate each of the following water uses?

Number of valid responses

73

Seven water uses were listed. The number listed beside each in the list below is the average of the numbers that water use was assigned in the 73 responses. The lower the number, the more that water use was preferred by the respondents. For example, agriculture, with an average ranking of 2.62, was the most preferred water use, and recreation, at 5.95, the least.

5.29	energy
2.62	agriculture
3.03	municipal
3.12	domestic
5.95	recreation
4.73	fish and wildlife
3.25	maintenance of water quality

5. *Should the Yellowstone mainstem be protected from the construction of large dams?*

<u>Number of valid responses</u>	<u>Yes</u>	<u>No</u>
84	71%	29%

6. *Should water be taken out of the Yellowstone mainstem to supply energy development in the Tongue and Powder subbasins?*

<u>Number of valid responses</u>	<u>Yes</u>	<u>No</u>
81	38%	62%

7. *Should water storage projects be constructed on these rivers:*
a) *Tongue River?*

<u>Number of valid responses</u>	<u>Yes</u>	<u>No</u>
80	90%	10%

If "yes", do you prefer offstream
or onstream

<u>Number of valid responses</u>	<u>offstream</u>	<u>onstream</u>
60	73%	27%

b) Powder River?

<u>Number of valid responses</u>	<u>Yes</u>	<u>No</u>
63	94%	6%

If "yes", offstream
or onstream

<u>Number of valid responses</u>	<u>offstream</u>	<u>onstream</u>
59	58%	42%

c) Yellowstone River?

<u>Number of valid responses</u>	<u>Yes</u>	<u>No</u>
67	73%	27%

If "yes", offstream
or onstream

<u>Number of valid responses</u>	<u>offstream</u>	<u>onstream</u>
54	93%	7%

Generally, should funding and construction of proposed water storage projects be federal, state, or private?

<u>Number of valid responses</u>	<u>federal</u>	<u>state</u>	<u>private</u>
62	35%	30%	35%

8. Should industry be required to:
a) use dry cooling in energy development?

<u>Number of valid responses</u>	<u>Yes</u>	<u>No</u>
71	75%	25%

- b) *store flood flows for use during critical low-flow periods rather than making year-round direct diversions?*

<u>Number of valid responses</u>	<u>Yes</u>	<u>No</u>
74	93%	7%

- c) *use deep ground water when possible?*

<u>Number of valid responses</u>	<u>Yes</u>	<u>No</u>
63	49%	51%

- d) *subsidize other users in its water development projects?*

<u>Number of valid responses</u>	<u>Yes</u>	<u>No</u>
55	51%	49%

9. *Would the impacts on fish and wildlife, water quality, and recreation associated with the high level of development be acceptable to you?*

<u>Number of valid responses</u>	<u>Yes</u>	<u>No</u>
81	31%	69%

10. *Do you think that there are major water-related matters in the Yellowstone Basin which were not satisfactorily addressed in this report?*

<u>Number of valid responses</u>	<u>Yes</u>	<u>No</u>
44	45%	55%

If so, what are they?

About twenty respondents suggested subjects which could have been more fully explored in the report. Several of these dealt with water rights and with the environmental and economic impacts of water reservations. Also mentioned were irrigation feasibility and associated water loss and a number of industry-related matters.

11. *How can the DNRC better involve the public on formulating the State Water Plan?*

Nearly all of the suggestions made in response to this question involved public meetings. It was suggested that they be publicized earlier, that the presentations be less technical, that the DNRC be more conscientious in incorporating comment received, and that information be made public for review well before the meetings. Also suggested was that the DNRC make better use of the media.

II

12. Are you a city/town or rural resident?

<u>Number of valid responses</u>	<u>city/town</u>	<u>rural</u>
89	47%	53%

If the former, indicate size of city: *less than 2500*
more than 2500

<u>Number of valid responses</u>	<u>less than 2500</u>	<u>more than 2500</u>
43	14%	86%

13. In which county do you live?

Thirteen Montana counties were represented in the response, as well as one county each from North Dakota and Wyoming. All are listed below, followed by the number of people who identified each as their county of residence.

Carbon	2
Custer	10
Dawson	10
Fallon	1
Gallatin	3
Park	29
Powder River	1
Richland	6
Rosebud	10
Stillwater	2
Sweet Grass	2
Treasure	2
Yellowstone	12
McKenzie, ND	1
Washakie, WY	1

In which of the subbasins identified in this report?

Only the Bighorn subbasin was not given by anyone in response to this question. The numbers of people who answered each of the other subbasins are:

Upper Yellowstone	23
Clarks Fork	1
Billings Area	10
Mid-Yellowstone	9
Tongue	4
Kinsey Area	6
Powder	4
Lower Yellowstone	11

14. Occupation:

Only three occupational categories were claimed by more than three people:

retired	12
rancher	17
farmer	11

Thirty other categories were identified, most of them by only one person. Of the thirty, most fell under the broad headings of agriculture, recreation, education, planning, business, and state government.

Organization or agency that you represent:

About 10 percent of the respondents identified an organization which they represented, although some qualified that by stating that opinions expressed were their own. Most organizations listed were state or local government bodies, such as the Department of Fish and Game, a local board of health, or a conservation district. Others were professional organizations, such as the Montana Well Drillers Association, and private groups, such as the Sierra Club.

III

16. a) *Would you like to be involved in the water planning process for the Yellowstone Basin?*

<u>Number of valid responses</u>	<u>Yes</u>	<u>No</u>
74	72%	28%

b) *If "yes", would you like to participate on a basin-wide or area-wide study and planning team?*

<u>Number of valid responses</u>	<u>Yes</u>	<u>No</u>
44	84%	16%

In what capacity?

<u>Number of valid responses</u>	<u>Advisory Committee</u>	<u>Technical Committee</u>	<u>Review & Comment</u>
51	27%	18%	55%

A fourth category, "other", was also included with some blank lines for explanation. Only three respondents took this option, and those responses are not tabulated here.

17. *Would you like to be on a mailing list to receive information relative to water planning in the Yellowstone?*

<u>Number of valid responses</u>	<u>Yes</u>	<u>No</u>
91	99%	1%

18. *Would you like to receive a summary of the response to this questionnaire?*

<u>Number of valid responses</u>	<u>Yes</u>	<u>No</u>
88	97%	3%

Because no attempt was made to provide a scientific sampling of Yellowstone Basin residents as respondents to the questionnaire, none of the recommendations presented earlier in this report are based solely on the response summarized above. However, general support for most of those recommendations is evidenced here.

Responses to several of the questions suggested significant--and sometimes surprising--attitudes among basin residents. For instance, that 82 percent of respondents, in response to question 1(a), favored extending the Yellowstone Moratorium until adoption of the State Water Plan shows substantial support for the philosophy behind the Water Moratorium Act of 1974. The responses to questions 1(d), 2, and 4 showed support for: establishing a legal defense fund for protection of water rights; guaranteeing some level of instream flows; and establishing a system of preferred water use.

In question 4, in which respondents were asked to indicate their preference ranking of a list of water uses, it came as no surprise that agriculture was the most preferred. It was surprising, though, that recreation was the least preferred, even behind energy, especially considering that many of the respondents indicated in comments elsewhere on the questionnaire that they are avid (even, in some cases, professional) hunters or fishermen. It is possible that respondents interpreted the word "recreation" as referring to camping, rafting, picnicking, and other activities participated in primarily by people from outside the local area.

Sixty-nine percent of respondents would find unacceptable the impacts on fish and wildlife, water quality, and recreation associated with the high level of development (question 9).

YOUR RESPONSE TO WHICH WAY? THE FUTURE OF YELLOWSTONE WATER

The purpose of this informal questionnaire is to solicit your opinion on the issues discussed in this draft version of Which Way? The Future of Yellowstone Water to assist the Montana DNRC in preparation of recommendations to the next Montana legislature. It is important that we know what you think; our recommendations must reflect public opinion. Remember, there is no right or wrong answer; respond to each question according to how you feel about it. If you have no opinion on some question, do not answer it. If you would like to make additional comments, please attach them on a separate sheet. All responses will be confidential.

I

Yes No

1. Regarding water rights in the basin:

- a) Should the Yellowstone Moratorium on large appropriations of water, which will expire in March of 1977, be extended until the State Water Plan is adopted? _____
- b) Should more tax money be expended to speed up the process of adjudicating water rights? _____
- c) Should more tax money be expended to assist local governments in applying for water reservations and in refining plans after reservations are granted? _____
- d) Should the state of Montana establish a legal defense fund to be used for the protection of existing and future water rights? _____

2. Before additional water is appropriated for consumptive use, should some level of instream flow be guaranteed to maintain fish and wildlife habitat, water quality, and recreation? _____

3. Identify the projected level of development (as presented in the report) that you would find acceptable:

	<u>Energy</u>			<u>Irrigation</u>		
	<u>High</u>	<u>Inter- mediate</u>	<u>Low</u>	<u>High</u>	<u>Inter- mediate</u>	<u>Low</u>
a) in your subbasin?	_____	_____	_____	_____	_____	_____
b) in the entire Yellowstone Basin?	_____	_____	_____	_____	_____	_____

4. In the future, should some uses of water be preferred over others? _____
If so, how, on a numerical scale using 1 to indicate first preference, 2 to indicate second preference, and so on, would you rate each of the following water uses?

- _____ energy
- _____ agriculture
- _____ municipal
- _____ domestic
- _____ recreation
- _____ fish and wildlife
- _____ maintenance of water quality

5. Should the Yellowstone mainstem be protected from the construction of large dams? _____
6. Should water be taken out of the Yellowstone mainstem to supply energy development in the Tongue and Powder subbasins? _____
7. Should water storage projects be constructed on these rivers:
 - a) Tongue River? _____
 If "yes", do you prefer offstream _____
 or onstream _____
 - b) Powder River? _____
 If "yes": offstream _____
 or onstream _____
 - c) Yellowstone River? _____
 If "yes": offstream _____
 or onstream _____

Generally, should funding and construction of proposed water storage projects be federal _____, state _____, or private _____? (check one)
8. Should industry be required to:
 - a) use dry cooling in energy development? _____
 - b) store flood flows for use during critical low-flow periods rather than making year-round direct diversions? _____
 - c) use deep ground water when possible? _____
 - d) subsidize other users in its water development projects? _____
9. Would the impacts on fish and wildlife, water quality, and recreation associated with the high level of development be acceptable to you? _____
10. Do you think that there are major water-related matters in the Yellowstone Basin which were not satisfactorily addressed in this report? _____
 If so, what are they? _____

11. How can the DNRC better involve the public in formulating the State Water Plan? _____

II

12. Are you a city/town _____ or rural _____ resident? (check one)
 If the former, indicate size of city: less than 2500 _____
 more than 2500 _____
13. In which county do you live? _____
 In which of the subbasins identified in this report? _____

14. Occupation _____
 Organization or agency that you represent _____

This page will be detached by the Department to maintain confidentiality in the questionnaire response.

III

- | | <u>Yes</u> | <u>No</u> |
|--|------------|-----------|
| 16. a) Would you like to be involved in the water planning process for the Yellowstone Basin? | ___ | ___ |
| b) If "yes," would you like to participate on a basin-wide or area-wide study and planning team? | ___ | ___ |
| In what capacity? | | |
| advisory committee _____ | | |
| technical committee _____ | | |
| review and comment _____ | | |
| other (explain) _____ | | |
| _____ | | |
| _____ | | |
| _____ | | |
| 17. Would you like to be on a mailing list to receive information relative to water planning in the Yellowstone? | ___ | ___ |
| 18. Would you like to receive a summary of the response to this questionnaire? | ___ | ___ |

If your answer to any question in Part III is "yes," please print your name and address below.

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